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CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

On the Condensation of Steam in the Cylinder due to Expansion.

By FRED. J. SLADE.

Much has been written of late to prove that the long received opinion, that a great economy is derived from working steam expansively, is quite fallacious; and, notwithstanding the vast amount of practical evidence in favor of the old belief from the well known results of most extensive practice, both in this country and abroad, many have had their faith shaken in the value of more than a very limited amount of expansion, partly by a few experiments perhaps not altogether free from sources of error, and to a greater extent, no doubt, by arguments put forth by persons who should have had great experience, and whose views therefore carried with them considerable *prima facie* weight. In this train of argument the main assumption has been that there is, as a necessary consequence of the act of expansion, a great condensation of steam in the cylinder, and this has been dwelt on in some instances till the most alarming effects would appear to result from it. Starting with a most singular fallacy as to the relative amounts of heat in steam of high and low pressure.* Mr. Isherwood has pictured to us how this condensation mul-

* Mr. Isherwood states, (p. 56, "Engineering Precedents," vol. ii:) "Although the total heat of steam of higher pressure is greater than the total heat of steam of lower pressure, yet, as the latent heat of the latter increases in a much higher ratio than its total heat diminishes, and as this increase in the latent heat is at the expense of the sensible heat, it (expansion) becomes a cooling process and produces the condensation stated." That is, after admitting that the total heat which includes and is the sum of the latent and sensible heat is greater in high than in low pressure steam, he claims that this greater total heat will not be sufficient for the less. He must forget that in lowering the pressure the sensible heat diminishes faster than the latent heat increases, and, *therefore*, it is that the total heat is less in the lower pressure steam. The diminution in the sensible heat yields up, so to speak, more heat than the increase of latent heat demands; hence steam expanded from a higher pressure without doing any work is slightly superheated.

tiplies itself beyond measure. Unfortunately, those who have written upon this subject have discussed it entirely in general terms, instead of bringing it directly to the test of numerical calculation, as it is possible to do, and thereby ascertaining exactly what the amount of condensation is, and what loss of power results therefrom.

The total heat of steam increases slightly with the pressure. If then steam could be expanded without being allowed to do any external work, as, for instance, by allowing it to expand into a vacuum, the steam after expansion would contain slightly more heat than was due to its pressure, or, in other words, would be slightly superheated. This fact has been beautifully illustrated experimentally by Professor Tyndall, using a vessel of compressed air, which, being allowed to expand into a vacuum, it was shown that the amount of heat absorbed in starting the particles of air into motion was exactly balanced by that given out in bringing them to rest again; and no other work being done, no heat was absorbed. This gain of heat in the case of steam is from 20 to 25 per cent. (according to the pressure) of the amount absorbed when the expansion takes place against resistance. In the steam engine, however, the case is different; for here the steam *does* work in expanding and absorbs an equivalent amount of heat, which has to be supplied by the condensation of a portion of the steam. The exact amount of heat required is readily found from an indicator diagram—every 772 lbs. of pressure through one foot of stroke requiring an absorption of an amount of heat competent to raise the temperature of 1 lb. of water 1° F. Now, it has been assumed that the expansion of the steam to fill the vacancy caused by the condensation necessary to supply this amount of heat, was the cause of a further absorption of heat and consequent condensation. That this is fallacious is evident when we reflect that the heat equivalent to the work done in moving the particles of steam is exactly replaced by the act of bringing them to rest again; just as a body moving in a vacuum gives out as much force in being stopped as it originally required to set in motion. Moreover, as the condensation of steam due to the work done reduces slightly the pressure, there is a slight excess of heat which goes to lessen, to a small extent, the condensation.

The force required to remove the particles after the piston, involves a disappearance of heat during the continuance of the stroke, and a consequent diminution of pressure. This heat, though given out again when the particles are brought to rest at the end of the stroke, is lost as far as direct power is concerned, but goes towards heating the piston and cylinder. The absolute amount of heat required in thus moving the particles of steam, is, of course, small, and yet as this loss has been urged as one of the objections to expansion, let us give it its exact value, which is found as follows: When the steam is cut off at half stroke, the work done in the act of expansion itself is the moving of all the steam in the cylinder through a distance equal to one-quarter the stroke, in the time of half the stroke. If cut off at one-third stroke it is the moving of all the steam a distance of one-third the stroke, in the time of two-thirds the stroke. If cut off at one-

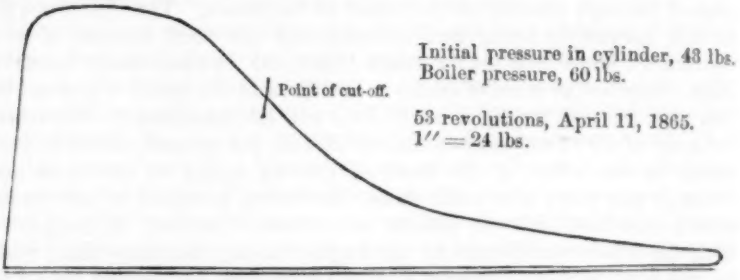
quarter stroke, the steam is moved three-eighths the stroke in the time of three-quarters of one stroke, and so on for other degrees of expansion, each of which would be equal to the whole mass of steam moved a distance of half the stroke in the time of one stroke, were the spaces moved through exactly proportional to the times. The difference due to this inequality being insignificant, and the total amount of work extremely small, we may assume this value as abundantly accurate. Now, suppose the mass of steam to be 1 lb. and the speed of piston 1000 feet per minute, then the work done will be imparting to this mass a velocity of 500 feet per minute, or 8·3 feet per second, which is about equal to the effect of the force of gravity acting on the same mass through one foot; the work done, therefore, is equal to one pound, raised one foot high—a totally insignificant amount in comparison with the whole work done by the engine during the same time, which in the case supposed might easily be 90,000 lbs. raised one foot. "The condensation due to expansion, *per se*," therefore does not amount to much.

When the exhaust valve opens, the particles of steam rush with great velocity into the condenser, and the acquisition of this velocity involves an absorption of heat. Suppose the pressure in the condenser to be one pound per square inch, and that in the cylinder at the commencement of the exhaust, 15 lbs. Then the work done by 1 lb. of steam in expanding through this difference of pressure will be 109,829 ft. lbs. = 142 units of heat. Of this, 37,872 ft. lbs. are employed in overcoming the head resistance in the condenser of one pound per square inch offered to the expansion of the steam. The remaining 71,957 ft. lbs., were the steam unimpeded in its flow, would impart to it a velocity of 2145 ft. per second. Owing to friction, &c., the actual velocity will always be less than this, and the difference between the number of ft. lbs. adequate to produce the actual velocity and that already given (71,957) is the measure of a portion of the work or heat that is returned to the steam and to the sides of the cylinder and pipes in the destruction of motion by friction.

Supposing the pressure at the end of the stroke to be equal to that of the atmosphere, the steam will have a total heat of 1178·6°, and if the temperature of the condenser be 104° F., corresponding to a total heat of steam of 1146·2°, the surplus of heat in the steam remaining in the cylinder during the exhaust stroke would be 32·4°, did it require no heat to set the particles in motion; but the quantity of heat required for this purpose being, as we have found, about 140°, the steam instead of being superheated is partially condensed and deposits moisture on the cylinder.

Now, let us take an actual example and apply the foregoing method of calculation to determine precisely what loss results from the various operations gone through during the stroke. The accompanying diagram is one of a number taken from a stationary engine, 10″ diameter of cylinder, × 20″ stroke, cutting off at about one-third stroke, by a slide on top of the main valve. The average pressure measured on the diagram is 34·5 lbs. The area of a 10″ piston =

78·5 inches, which, multiplied by 34·5, gives 2708·5 lbs. raised 20 inches as the work done by the steam used in one stroke equal to 4514 lbs. raised one foot. This amount of work is equivalent to $5\frac{7}{8}$ units of heat.



The pressure in the boiler was 60 lbs. above the atmosphere, and the initial pressure in the cylinder, 43 lbs. Assuming the gain of heat due to this expansion to have been neutralized by radiation from the steam pipe and chest, we have next to consider the gain of heat from a reduction of pressure from 43 lbs. to 4 lbs. above the atmosphere, which is (1202·5°—1182·7°=) 19·8°. The capacity of the cylinder is ·9086 cubic foot, and the weight of a cubic foot of steam at the pressure of 4 lbs. is ·044 lb. The contents of the cylinder, therefore, weighs ·04 lb., and the increase of 19·8° in this quantity of steam is equal to ·8 of a unit of heat which, deducted from the $5\frac{7}{8}$ units of heat required to do the work, leaves still about 5 units to be supplied by the condensation of the steam. The latent heat of steam of 34·5 lbs. pressure is 934°, and therefore to obtain 5 units of heat, it will be necessary to condense ·0055 lb. of steam or about $\frac{1}{8}$ of the total quantity contained in the cylinder. The gain of heat due to the reduction of pressure arising from this condensation will act to diminish the condensation by about $\frac{1}{80}$ of itself—a quantity too small to be considered in view of the inherent uncertainties of the case, making it impossible to tell from a diagram *exactly* how much steam has been admitted to the cylinder. The pressure at the end of the stroke is 4 lbs. above the atmosphere, or 19 lbs. total pressure. After the opening of the exhaust valve, it falls to 16 lbs. equal to an enlargement of its volume from ·9086 cubic feet, to 1·08 cubic feet. The work done in this expansion is 406 ft. lbs. To raise a column of atmospheric air of an area of 144 square inches, ·171 feet, or, in other words, to overcome a resistance of 2160 lbs. through that distance = 369 ft. lbs. of *external work*. The remaining 37 ft. lbs., minus that absorbed in friction, is the *internal work* of imparting to ·171 cubic feet of steam of 16 lbs. pressure the velocity with which it was ejected by expansion from the cylinder. This velocity we may take as about 400 feet per second, to acquire which a body would have to fall through 2496 feet. The weight of ·171 cubic feet of steam of 16 lbs. pressure being ·0065 lbs. the work done is equal to 16·5 ft. lbs. The sum, therefore, of external and internal work done in exhausting is 385·5 ft. lbs., equal to

one-half a unit of heat, to supply which will require the condensation of ·00052 lb. of steam.

We have thus considered the action of the steam through every portion of the stroke and have found by definite calculation the loss or gain of heat in each operation. We have seen that the principal and only considerable loss of heat is that necessarily abstracted in the act of performing the work—this, of course, is constant for the same amount of work, whether we use the steam expansively or follow full stroke. The work required to drive the particles of steam after the piston in expanding has been shown to be absolutely insignificant, but even if it were of any account, it would operate against the full stroke engine, as in this case a larger mass of steam has to be set in motion. On the other hand, we find that there is a slight gain of heat due to expansion, *per se*, equal in the case we examined to one-seventh the amount required to do the whole work. If this investigation may do anything towards freeing this subject from vague speculations and substituting sounder modes of reasoning, it will not have been undertaken in vain.

Experience, if it be intelligently comprehended, is the safest guide in all such matters; but it helps us in interpreting experience, and suggests new directions for experiment to apply the known laws of physic to obtain a theoretical solution of the problem.

Dry Dock Iron Works, New York.

For the Journal of the Franklin Institute.

The Bourdon Pressure Gauge. By John D. Van Buren.

The essential parts of this gauge are an elastic steel tube bent in the form of an arc of a circle, fixed at one end, and having an elliptical cross section, with its major or longer axis perpendicular to the plane of the circle, together with an index hand connected with the free end of the tube. The elastic medium of which the tension is to be measured is allowed to flow into the tube, and the pressure which it exerts upon its interior surface has a tendency to straighten the tube. The tube, having its external surface exposed to the atmospheric pressure, is generally so adjusted that its readings commence from that pressure as *zero*, *i. e.*, when the internal is equal to the external pressure, the gauge reads 0. If the internal pressure then be diminished below the atmospheric, the tube, in place of straightening, will *coil;* thus forming a *vacuum* gauge, or gauge for pressures less than fifteen pounds per square inch. The *steam* gauge reads the degree of pressure *above the atmospheric pressure at the time.* Fig. 1. It is proposed to explain the action of this gauge.

Fig. 1.

Action of the Gauge.—The elastic medium, such as steam entering the tube, will tend to occupy the greatest possible volume. It will, therefore, tend to so

alter the shape of the containing vessel that, with its given bounding surface, it shall have the greatest possible capacity. This is the principle upon which the gauge is constructed. This change of shape causes the tendency to straighten in the tube. Let Fig. 2 represent a meridional section of the tube, *i.e.*, a section by a plane passing through the minor axes of the elliptical sections. Suppose $a\ b$ and $a_1\ b_1$ to be the minor axes of two consecutive sections, represented also in Fig. 3 by $a\ b$. From what has been stated above, it is evident that, upon the admission of the steam or other elastic medium, these sections will have a tendency to assume the form of a circle, since with a given perimeter this figure gives the greatest area, and thus, with the given surface, to give the maximum capacity to the tube. But, in order that these sections may assume the form of a circle, the minor axes $a\ b$ and $a_1\ b_1$, Figs. 2 and 3, must extend. If these sections were perfectly free and independent of each other, this extension would take place in the *radial* lines $a\ b$ and $a_1\ b_1$. The sections are, however, bound together by the material of the tube, which opposes a resistance to the free motion of the points $a\ b$, $a_1\ b_1$. In order to allow the point a to move to c, and the point a_1 to c_1, the filament of metal $a\ a^1$ must be *extended* into $c\ c_1$; and to allow the point b to move to d, and the point b_1 to d_1, the filament of metal $b\ b_1$ must be *compressed* into $d\ d_1$. But the resistances of the material to extension and compression will oppose this action, and therefore the points $a\ b$, $a_1\ b_1$, will take intermediate paths and arrive respectively at the points $x\ y$, $x_1 y_1$, the tendency being to preserve the lengths of the filaments of metal $a\ a_1$ and $b\ b_1$, making $x\ x_1 = a\ a_1$, and $y\ y_1 = b\ b_1$. The *exact* directions could be found by constructing parallelograms upon lines representing the respective radial and circumferential forces and taking the diagonals for the paths of the points $a\ b$, $a_1\ b_1$, during the extension.

Fig. 2.

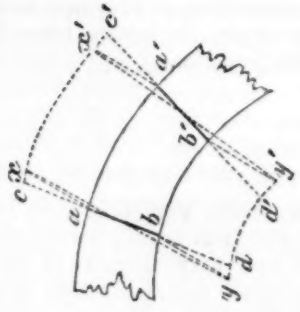
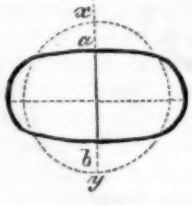


Fig. 3.

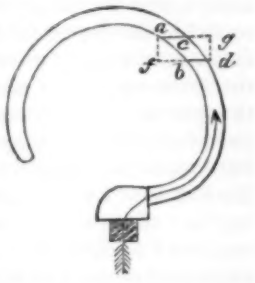


Now, joining the points $x\ y$, $x_1\ y_1$, by straight lines, it is plain that the consecutive axes $a\ b$ and $a_1\ b_1$, *after extension*, will be represented by the lines $x\ y$ and $x_1\ y_1$, *less inclined than before to each other;* hence, the tube must have *straightened* or uncoiled to a corresponding extent, since the same may be proved for any other meridional section, taking chords in place of the minor axes. In the case of the vacuum gauge, the pressure being diminished within, below the atmospheric pressure, the section will become more flattened, and the tube will *coil up* a corresponding amount; for the filament $a\ a_1$ will be

acted on by a compressive strain, and the filament $b\,b_1$ by a tensive strain, the reverse of the above.

Note.—The writer has frequently heard the following given as an explanation of the action of this gauge: The steam pressure pressing *from* has a greater area to act upon than the steam pressure pressing *towards* the centre of curvature of the tube, by reason of the outer circumference being greater than the inner circumference of the bend of the tube; and hence the tendency to straighten in the tube under an increased pressure. If this were true, then perpetual motion were indeed a fact; for, forming a car in the shape of the crescent moon, and filling it with compressed air, we could fly even to its heavenly prototype, with the rapidly increasing velocity due to an unceasing constant force, unchecked by the ugly fact that reaction and action are equal and opposite,—unincumbered by coal or engine,—could make motors (prime) of our boots by tugging at the straps. This explanation does not at all notice the change of shape of the elliptical sections. Now, consider the elementary areas *a b* and *c d*, included between the parallel lines *a c* and *b d*, Fig. 4, and suppose no change to take place in the shape of the section. It is evident that the forces tending to push the areas *a b* and *c d* in the directions of the parallel lines are equal and opposite, being measured by the *equal* projections *a f* and *d g* of the surfaces *a b* and *c d* upon a plane perpendicular to these lines. The same may be proved for any other two sections, and for any direction; and hence no motion can ensue *unless the forces of tension and compression are brought into play by a change of shape in the section of the tube.*

Fig. 4.



On Marine Engines from 1851 *to the Present Time.*

By N. P. Burgh, Esq., Engineer.

From the Journal of the Society of Arts, No. 643.

(Continued from page 312.)

Discussion.—Mr. J. Clarke said allusion had been made to surface condensers, which, he presumed, would render unnecessary the use of salt water in the boiler, inasmuch as the boilers could be charged with fresh water before leaving the port, and this was used over and over again. He was recently in the workshop of a member of the Society, who was largely engaged in the manufacture of salinometers, having then a large order to execute for the government; but, in the event of the universal adoption of surface condensers, he presumed that instrument would be superseded.

Captain Jasper Selwyn, R.N., said, as a naval officer interested in the progress of mechanical invention, he thanked Mr. Burgh for the information he had afforded in his interesting paper. He would remark, in the first place, that only very slight mention had been made of boilers; but a man who took the interest, as Mr. Burgh evidently did, in mechanical questions, would never ignore the source of the power, or deem it unworthy of a place in his paper; for it was clear, so long as we went on with ineffective arrangements to produce the

power itself, it mattered little how much economy was introduced into the arrangements for utilizing the power. The steam boilers of the present day he considered to be a reproach upon the marine engineers of this country. They were very far from producing, at any time, any thing like the results in practice which they produced when sent on trial trips. That was partly caused by the insufficient means of securing the circulation of the water in the boiler, and partly by the bad arrangement of the fuel for firing, by the choking of the tubes with smoke, and by the galvanic action which was speedily set up and resulted in the deposit of large quantities of material all over the heating surfaces. In many ways the boilers required, but had not yet received, the same amount of attention that had been given to the engines. He thought improved means for securing the circulation of the hot water, and of preventing escape, of utilizing fuel, and obtaining complete combustion, were of more importance than any improvement in the engines. He had heard of the introduction of steel with great pleasure, knowing how advantageous it would be in many respects; but if those who employed steel did not consider the electrical action which would result when that metal was brought into contact with copper, a deposit would be produced in the boiler which would go far to neutralize the other advantages. He was very pleased to hear incidentally introduced into the paper a subject in which he had for some years taken an interest, viz: that of twin screws. He was, however, at a loss to conceive on what ground it was said that the twin-screw principle could only succeed in vessels of a certain size, and was not applicable to larger ships. No later than the previous day, the newspapers gave an account of the trial of a vessel of 970 tons, fitted with twin screws, and the results, he had been informed by persons who were present, were correctly reported. Now, that vessel represented what would formerly have been called a large ship, and the question to be decided was to what tonnage were the good effects of twin screws to be limited? In the first instance, it was said that the principle was a good one for boats, and last year Mr. Rennie stated it had been tried with excellent effects in small river steamers, but he doubted the success of its application to any thing beyond that. Subsequently to that, however, blockade runners fitted with twin screws made their appearance, and were completely successful, and since then the experiment had been tried on a still larger scale by ship-builders on the Thames. He deprecated such a decision being arrived at on this point as would prevent us from building vessels for our navy of such steering power as Mr. Burgh had recognized in the twin screws; besides this advantage, he (Capt. Selwyn) maintained there was also an increase of speed. They had a certain draft of water in a screw ship to which they were limited; they might put into the ship engine power as much as they pleased, but they could only utilize the area of water which came against the propeller. If they could increase that area they got more duty done by the engines without "churning" the water, and that was the whole theory of the success of twin screws in giving speed. That principle was perfectly applicable to a ship of war; and the vessel to which he had previously

referred had another valuable quality: she gave, with a draft of nine feet six inches, a speed of 16¾ knots with both screws working, and of 12 knots with one screw only working. This showed that even in that vessel the power of propulsion was not utilized to its full extent; the increased velocity did not correspond to the increased horse power used. With regard to the observations in the paper, as to the reluctance of men to copy, he confessed he thought that class of intellect was more rare which knew how to judge properly what to copy, than that which invented for itself a new mode not always better than that which preceded it. The great masters in painting had numberless followers, who called themselves the scholars of those men; and it was no less a credit to these to have chosen well their master than to have produced something original. With regard to the comparison of fuel consumption, it must be recollected, when they got indicated h.p. in proportion to nominal h.p., as 4 or 5 to 1, and the coal burnt was now 2¾ lbs., instead of 8 or 9 lbs. per h.p., there was not so very great an advance as might be inferred from the way in which the case had been put. Much more might be done in the way of economizing fuel, by due consideration of the best way of placing the heating power advantageously in the boiler. It was clear, so long as they did not provide for the free descent of the hot water when it had given off its steam, and had become to a certain extent cool—the free descent from the top to the bottom to be re-heated—so long they lost the good effect of the boiler. The injurious effects of scale in boilers had been obviated to a certain extent by the employment of scale catchers or surface apparatus for laying hold of the scale as it floated up, but he thought the better way was to consider any system which formed less scale in the boiler, and with that view fresh water, when once in the ship, might be maintained in the boiler without trouble. They could produce sufficient fresh water for the purpose by the utilization of a small quantity of fuel, so as to supply whatever waste of water took place from condensation. With regard to the general arrangement of engines in ships, he quite entered into the graphic illustration in the paper of a man hung by his heels to inspect the foot valves. He thought engines were made too much like watches. Engineers prided themselves on the small space within which they could place their engines, and by that means subjected the persons who worked them to a great deal of unnecessary inconvenience.

Mr. Rochusson, as one practically connected with the manufacture of machinery, would express his dissent from the statement of the last speaker, that the contact of steel and copper in a boiler would generate a stronger galvanic current than that of iron and copper. [Captain Selwyn said he had made no such statement.] There was no doubt that steel was a very important element in all engines, and he regretted that subject had not been more dilated on in the paper; at the same time, it was well to give a caution as to the indiscriminate adoption of steel for boilers. Steel would bear a higher tension than the best Yorkshire iron, but certain qualities of steel were unfit for boilers from their liability to injury from blistering. The most suitable form of steel for

boilers was cast steel, which could be made of a strength equal to a pressure of sixty tons to the square inch. One great object sought in engines was the avoidance of heated bearings; and the more they reduced the surface of the bearings, and the more they employed metal capable of a highly polished surface, the less were they liable to this evil. The use of cast steel for shafting, was, therefore, a great advantage. It had been found by experience that a cast steel shaft of 9 inches diameter, was equal in strength to one 11 inches in wrought iron. In that proportion, therefore, they saved material in the weakest part of the ship, and they had a stronger construction with less strain upon the engine. They might go from that to cast steel propellers. There was scarcely a greater annoyance on a voyage than the breaking of a propeller. In one short voyage in one of his vessels no fewer than five cast iron propellers were broken. They were not, perhaps, at that time quite up to making good cast steel propellers, but he believed they were so now. The first cost would be greater, but that was more than compensated by the safety and durability which were insured.

Captain SYMONDS, R.N., reverting to the subject of the twin screw, said that Mr. Burgh, while giving credit to that system for a certain number of advantages, had omitted two or three of the most important. During the last five or six years he had seen something of the practice of the larger class of the twin screw vessels, and it struck him that one of the principle advantages of the twin system was that, in the event of one engine or one screw becoming injured, they had the use of the other engine and screw, by which two-thirds of the power could be obtained in case of emergency. This was exemplified in the trial of the vessel alluded to by Captain Selwyn, when one of the engines being stopped, owing to heated bearings, she was propelled at twelve knots with the other engine; her full speed being rather over sixteen knots. That was a very important thing, especially in a merchant ship, as had been proved in a voyage to America. A twin screw ship had been able to proceed with fair speed and slight consumption of fuel with one engine, while the other engine was being repaired, so that when she arrived out, her engines and boilers were in a good condition to run the blockade without any occasion for delay. If that ship had had only one pair of engines applied to a single screw, it would not have been so capable of performing this service. With respect to the limit of size of ship to which the twin system was applicable, his gallant friend Captain Selwyn's remarks on the subject rendered it unnecessary for him to go over the same ground again, but he would add that it was of the utmost importance to have the twin system adopted in heavy ships in order to divide the power between two engines, which ordinary engineers would then find no difficulty in manufacturing; besides, it was found difficult on board ship to lift out the heavy parts of very large engines for repair. He submitted, also, that the moving parts of these large engines in heavy ships were not so convenient as lighter machinery would be. Another great point was the difference in the amount of friction between the heavy single screw

engines and the lighter engines on the twin system. In addition to these advantages, there was that which was derived from the position of the twin screws, away from the centre of the ship, which not only gave them a great advantage in propulsion, but also placed them away from the extreme end of the dead-wood, where, from the longer leverage, greater vibration would necessarily be produced. In fact, the single screw produced an amount of vibration which was avoided in the twin-screw system. Experience had shown that the twin principle had been applied with the best results to vessels of various sizes up to 500 tons, and within his own knowledge one of these vessels had been doing regular work in towing for the last six years. With a draft of only 3 feet 3 inches, and engines of 30 horse power, she had been continually towing four Dutch barges, with loads of 50 tons each, at 6 knots an hour, which was a result, he believed, seldom obtained by paddle-wheel tugs of the same power and draught of water. The engines were in as good a state as when they were first built, and they had never been known to hang on the centre, which was one of the objections to the single screw engine. He had found the twin system effective for two main reasons. In the first place, the arrangement of the inverted cylinder engines on the A-frame occupied no more room in the ship than a pair of ordinary screw engines, with this further advantage, that it did away with even the slight vibration which was found in vessels of the same character with the engines laid horizontal. He submitted these were points of advantage which ought not to be lost sight of.

Mr. G. F. Wilson, F.R.S., remarked that on the first introduction of surface condensers a difficulty was experienced, which he should be glad to hear had been obviated. It was found that the oil used for lubricating certain parts of the engine, was carried with the water into the boilers, and there, as was well known to chemists, when oil and water were brought together at a high temperature, the oil became separated into its acids and base, the acids being free to act upon the material of the boiler, and upon any impurities contained in the water. This was found to be an important objection to surface condensers. He should be glad to know whether that objection had been removed. In addition to this, the steam was not generated so quickly. It was proposed at one time to use oil not composed of acids and a base, such as mineral oil, which, it had been thought, would not be decomposed by the action of the water, but he had no means of knowing whether this succeeded or not.

Mr. John Grantham remarked that the double-screw system had entered somewhat largely into this discussion. It was a subject of great interest at the present time, and the naval officers who had addressed them had spoken encouragingly of its advantages. There were to this question, as to all others, two sides. The system seemed to be a very captivating one, but he thought its advantages had been somewhat overrated, and they must be cautious not to take up too readily the few examples, which had been presented under perhaps the most favorable circumstances that could be obtained, and to suppose that the system, therefore, had all the merits which those particular vessels

were shown to possess. The builders of those ships understood their business well, and built fast vessels to which they applied the twin screws, and we did not always weigh carefully how the great success had been produced, and whether the same results, or nearly the same, might not have been produced by the single screw. It was, therefore, not unnatural that naval men, who had to do principally with ultimate results, should be very much taken by these experimental vessels, but, he feared, when they had longer experience, some of those advantages would smooth down. As yet there was no proof that two screws would propel a vessel better than one, all other things being equal. He admitted that, if they had a vessel of light draught, and put very high power into it, probably two screws would show a better result than one, from the fact that they gave a larger surface under more favorable circumstances for propelling the vessel and utilizing the power given to her. But he asked the engineers and naval men present to consider all the circumstances of the case. If they wished to have a screw vessel of light draft and great power the double screw might be best, but if they were not limited as to draught of water, and did not require excessive power, the single screw would be best. One disadvantage of the twin-screw system was that it made the interior of the ship more difficult to deal with than when there was only one shaft and one set of machinery. If they could apply all the power favorably to one screw, he thought it desirable to do so. It would not, however, do to dogmatize on this subject, and, whilst he would not advise them to neglect this question altogether, he would caution them against thinking the system possessed all the advantages which had been urged in its favor as having been exhibited in the very fast and well built vessels which had been recently brought before the public.

Mr. W. Hawes confessed his surprise at the observation of one of the naval officers who had spoken, that he considered the boilers on board a great many of our ships were a disgrace to the present state of science. When they found it to be the fact that the quantity of fuel consumed had decreased from an average of 5 lbs. or 6 lbs. to $2\frac{1}{2}$ lbs. per indicated h. p., he thought it showed a great amount of progress. That result might be obtained, not simply by having the best form of boiler and the best mode of applying the fuel, but likewise by the perfection of the machinery which was driven. The measure was the fuel required, not to evaporate a given quantity of water, but to drive an engine of a certain power. That engine would be driven with the less steam, the more perfect was the machinery; therefore, the consumption of fuel was not only a test of the efficiency of the boiler, but also of the machinery which was driven by it. Undoubtedly, he agreed that the economical utilization of fuel was one of the most important elements of progress in marine engines. There were two difficulties staring the engineer in the face: first, how to put the largest amount of available power on board a vessel of a given size; and, secondly, how to stow sufficient coal to make that power effective for a long voyage. In all long voyages, the period during which a vessel could run under steam was so limited, that it was a matter of the greatest importance

to make arrangements by which a supply of fresh fuel could be ensured at frequent stations. For his part, he believed the progress in the construction of boilers had kept pace with the improvements that had been introduced into steam machinery, and that our present boilers, so far from being a reproach to our engineers, were evidence that they had been as successfully occupied in this branch of manufacture as they had in the production of the most perfect machinery the world had ever yet seen. With respect to the twin-screw system, he was inclined to think if that plan had hitherto been the ordinary one for propelling vessels, and the single screw introduced for the first time, we should be struck with the simplicity of the machinery required in the latter instance to produce the same results. In the statement of the work done by the twin-screw ships, there was an omission of the speed obtained by each vessel; but in the table by Messrs. Penn, this information was given. The very feature by which alone we could judge of the real value of the twin system was omitted. The adoption of twin screws, it was to be remarked, involved a double risk of fouling, and if there was one difficulty more than another with regard to screw ships, it was the accidents which happened to the propellers from fouling with substances floating on the water, and certainly two small propellers were more likely to be injured in that way than one large one. Moreover, the hold of a vessel was better adapted for one pair of engines with one shaft and one screw, than for having all those parts duplicated, and consequently, weaker and more liable to derangement. Although there might be advantages in this system for shallow waters and light draft, he believed, where the screw was well immersed, the single propeller was more effective. They could not but feel much indebted to Mr. Burgh for bringing this subject before them; whether connected with war or peace, with the navy or the merchant marine of the country, there was scarcely a question of equal importance to the nation. It was essential that we should have the best ships, the best boilers, and the best engines, to enable us to perform the longest voyages in the shortest time, with the least amount of risk to the lives and cargoes conveyed.

Captain SYMONDS begged to state that there had been no instance recorded of the fouling of twin screws, and he believed that they were far less liable to foul than the single screw.

The CHAIRMAN said, looking to the title of Mr. Burgh's paper, they must all agree that a very fair description had been given of what steam engines were in the year 1851, and of the improvements that had taken place at that time. To go into all the details of this subject would far exceed the limits of a paper; but, nevertheless, it had led to an interesting discussion, and in itself conveyed a great number of valuable details. The question of twin screws was, perhaps, the most important one that had been touched upon, and he agreed with Mr. Grantham that in an ordinary passenger and cargo or mail ship, with considerable draft of water, the single screw would probably give as efficient results in speed and economy of power as the double screw; but where a great amount of power was required to be applied to a

vessel of limited draft, as was the case with blockade runners, the double screw might do more than could have been done with a single one, and he would further express an opinion that, in the manœuvring of ships of war in action, the double screw system, no doubt, conferred many advantages. He might remark, that Captain Selwyn appeared to be a little mistaken with regard to the consumption of fuel. He understood Mr. Burgh to state that the consumption of coal had been reduced from 7 lbs. or 8 lbs. per indicated horse power as low as 2½ lbs. Perhaps the first was rather too large a figure as applicable to ten years ago, but his own impression was that the engines of good makers had worked with a consumption of not more than 1½ lbs. to 1¾ lbs. per indicated horse power, which, compared with ten years ago, was a very great saving, and he thought our marine engineers ought to be gratified rather than otherwise, that they had thus far succeeded in economizing fuel. He now begged to propose a vote of thanks to Mr. Burgh for his interesting paper.

The vote of thanks having been passed,

Mr. BURGH acknowledged the compliment, and in reply upon the discussion, said he thought the advantages of the twin-screw system was principally connected with the facilities for steering. With regard to the size of ship to which that system should be limited, it was impossible to lay down any rule, because it must be borne in mind that it was more than probable that very heavy ordnance would be brought into use on ship-board, so that very large vessels would become necessary, and then increased steerage power would be most valuable. The problem to be solved was whether the twin-screw system admitted of universal application regardless of size and other conditions. Of that, he repeated, he required more evidence than had as yet been presented to him. With regard to the question that had been asked as to whether the accumulation of scale in the boiler had been prevented, he would say if they used proper water in the boiler when they commenced working it, and if they took a sufficient supply of it to obviate the necessity of using dirty salt water, employing, at the same time, surface condensers, the scale in the boilers would be very greatly reduced. In reply to Mr. Wilson, he would say, he thought the water was generally taken from the condensers, where but very little oil was presumed to be. Sometimes, it was true, in lubricating the internal portion of the cylinders, a certain portion of oil would get into the condensers, but not to an extent likely to prove injurious to the boiler.

At the conclusion of his remarks, Mr. Burgh explained the action of the equilibrium slide-valve, and described the models and drawings lent by the several firms named in the paper, to whom the thanks of the Society are due.

Peculiarities of Indian Engineering. By Major J. G. Medley, R.E.

From the London Civil Engineer and Architect's Journal, August, 1865.

In this paper I propose to draw attention to some of those peculiarities in Indian engineering, which will serve to show the conditions under which work has to be executed in this country, (India,) and how far they differ from English methods. The sketch will not, perhaps, be altogether destitute of interest to many who are in India.

First, as to the agency. Except forts, arsenals, dockyards, barracks, and the like, there is scarcely a single public work in England in which the Imperial Government is directly interested; for even such works as jails, roads, &c., belong to the counties, or to recognised local interests, while the great mass of important works, such as railways, harbors, &c., belong to joint stock companies, and are private property.

In India, the government is the constructor and maintainer of nearly every public work throughout the country. Not merely works which specially appertain to an immense military establishment, but every road, bridge, church, court-house, jail, &c., has to be built from Imperial funds, and through government officers. Nor can even the railways be excepted, for, though the capital employed is not its own, yet the controlling power possessed by government is so great,* that not the smallest work can be undertaken, nor the salary of the least official paid, without its written authority.

For the above work, a great department of state, the Department of Public Works, is specially provided, by which a systematic control is maintained over a vast body of officials, European and native, acting as engineers, overseers, &c., from the secretariat down to the meanest employee.

But another distinctive difference between the agencies employed in England and India is, that in the former country, work is executed almost invariably by contract, while in the latter, daily labor employed and paid by the engineers is as invariably used. It is true that every effort is being made to introduce the contract system, and that it is generally in vogue in the presidency towns, and on most of the great railway works, but over the whole country the vast mass of the government work is done by daily paid labor, and the extra work thereby thrown upon an engineer may be easily conceived.

In another very important matter do the functions of the Indian engineer differ much from his brother in England. In many parts of the country there is no organization of labor whatever, and, when works have to be executed, the engineer has to collect and train his

* This arises from the guarantee system under which the capital has been raised, the government guaranteeing a minimum rate of interest (5 per cent.) to the share holders on all sums passed to capital account. The controlling power is exercised through the government consulting engineers, who have a veto on almost every action of the company's engineers. The system, though perhaps the best that could be devised at the time, has been productive of much delay and no little dissension. It would be a preferable course for government to grant a certain subsidy to the railway company for every mile of line, as completed and open for traffic, and some such arrangement will probably be adopted in future.

workmen, to make arrangements for carriage,* to make his own bricks, burn his own lime, cut his own timber, and, in a word, superintend a hundred petty details, which, in a civilized country, are undertaken by a hundred different men, each skilled in his own peculiar business.

Of the workmen themselves, much good may be said. That they have the usual prejudices of ignorant men to the introduction of new ideas, and new methods of working, is to be expected, but they are not worse than others in that respect, and if well managed are, as a rule, both intelligent and teachable. Excellent masons, carpenters, and smiths abound in the country. The machinery in the various railway workshops is managed by natives under European superintendence, and though there are no native engine drivers as yet, we shall doubtless have some before long.†

The most striking thing to the engineer fresh from England is the total absence of the ordinary mechanical appliances for executing work. Vast earthworks are still made by the help of the phourah, or native spade, and baskets carried on the heads of women and children. Wheelbarrows are scarcely ever seen; horse carts still more rarely. For getting water out of foundations, &c., pumps are coming into use, but in general, the primitive native modes of baling, or the churus (leather bag,) or Persian wheel worked by bullocks, are still employed. Bricks and tiles are almost invariably hand-made, and the pug-mill unknown; the saw pit is never used.

Of course, the principal reason for this is the comparative cheapness of labor, but if the rate of labor increases for a few years longer, as it has done for some time past, the introduction of more elaborate appliances will become essential. At present, except the railway workshops and those established at Roorkee, there is no steam machinery in the country, unless at the presidency towns. Machines driven by wind power are also unknown; it is difficult to say why. Of the enormous water power available on the numerous canals and rivers, very little is utilized. Sawing machines are here and there put up, and

* This difficulty of carriage alone, in a country where the distances are so vast, and the means of intercommunication so incomplete, is most serious. The greater portion of the permanent way of East Indian Railway, was brought by native boats up the Ganges, and £100,000 worth of rails, &c., now lie at the bottom of that river. On the Punjab Railway, the materials were brought in boats up the Indus, which were often seven months on the voyage, (800 miles,) the cost of freight between Kurrachee and Moulton being double the freight from England to Kurrachee. The locomotives after getting to Moulton, were dragged up an unmetalled road to Lahore on trucks, by elephants and bullocks—six weeks being occupied in accomplishing the 200 miles. On this line too, which runs through a desert, the first steps of the engineers were to dig wells and build huts for the work-people, and induce grain merchants to live in the desert to supply their wants. When the writer went down to inspect the first trace of the line with the chief engineer, water and provisions had to be carried on camels to supply the whole party.

† In the railway workshops at Lahore, a short time ago, I saw the carpenters working at regular benches instead of in their own squatting position and turning out some beautiful specimens of work. The whole of the rolling stock (except the iron work, which is brought from England) has been made at Lahore for this line by native workmen. At Goojranwalla I saw a Colt's revolver, copied so exactly, even to the engraving on the cylinders, that only very close inspection could tell it had been made by a native smith.

the common punchukkee, or native corn mill, is everywhere seen where there is an available fall. Machinery worked by animal power is confined to water raising for irrigation purposes, and to one or two primitive inventions employed in manufactures.

Having said so much of the agency employed, let us glance at the materials used, and the works turned out. In Central India and the hilly districts all over the Continent, many varieties of excellent building stone exist, and are abundantly used. In the great plains of Bengal, Hindostan, and the Punjab, however, brick is the only available material. The English sized bricks, or those of a still larger size, are now coming into general use. The native bricks are very small, excellently burnt, laid with little attention to bond, and with a profuse expenditure of mortar. Bricks are burnt with wood fuel,* in kilns of several kinds; or in stacks like English clamps, with dried cow-dung instead of coal.

Excellent lime is everywhere abundant, produced either from limestone, *in situ*, or the boulders found in hill torrents, or the kunker found in the plains. It is mixed with various substances for mortars, of which pit sand and soorkhee (pounded brick) are the chief ingredients. For very strong or fine mortars, coarse sugar and egg shells are sometimes added.

A great variety of fine timber is found in India, generally brought from the forests in the hills—among which may be noticed saul, a dark, heavy, straight, and strong wood, and deodar, nearly the same as the cedar of Lebanon; the former used in the North West Provinces, the latter in the Punjab for every kind of building purpose. Both of these are found in the hills alone, at an elevation of from 2000 to 5000 feet; the trees are cut down and thrown into the rivers, and when these rise, the logs are floated down to the plains. In West and South India, teak is in general use. It abounds in the forests of Burmah, being one of the most valuable productions of that Province. Toon, an inferior sort of mahogony, is extensively used for furniture; sissoo or sheeshum, and some of the varieties of acacia, are hard, heavy, crooked woods used for strength and toughness.

Iron ores of fine quality are abundant in many parts of India, but from the want of fuel and carriage are little worked, and English iron is generally used. Government have made, and are now making, several praiseworthy attempts to develop the manufacture of iron.

Here it may be as well to note one or two specialities of construction employed in India.

In roads, stone metalling, laid as in macadamised roads, is common enough, but in the great plains of Upper India the peculiar material kunkur is used, and laid in a peculiar manner. It is a species of concretionary oolitic limestone, found in beds close to the surface, and has to be drenched with water, rammed quite smooth, and then suffered to dry before any traffic is admitted. It then makes a white,

* Except in a few places where coal is found. No coal worth working has yet been discovered in Northern India. The locomotives burn wood, and fuel is scarce and dear.

smooth, and very excellent road covering. In Southern India, laterite and moorum, a sort of red gravel, are commonly employed.

In foundations, piles are rarely employed, for so many destructive agencies are at work that they would not be lasting. The majority of the water courses are nearly dry at one time of the year, and this affords great facilities for getting in the foundations of bridges or other works in the water. For these, the general substitutes for piles are masonry wells or blocks, which are sunk close together, arched over, and on them the piers and abutments are raised; they are also used as foundations for houses in places where the soil is very treacherous. The beds of most rivers in Northern India when bored, show sand to an immense depth. In Bengal alluvial mud is found to as great a depth, and necessitates as much precaution as sand. The dry state of the river beds also gives great facilities for turning arches without the use of expensive centerings. A simple arrangement of dry bricks and timbers are constantly used, built up in the bed of the stream; of course the work is subject to accidents from sudden floods, but these are very rare.

The greatest works as yet executed in India belong, as in England, to the railways. Indeed there are none in the world more interesting or important than the Bhore Ghaut Incline, the Soane and the Jumna Bridges, and other works little inferior to them which might be enumerated. The East Indian Railway, 1000 miles long from Calcutta to Delhi, with the branch to Jubbulpore now under construction, is probably the longest line in the world owned by a single company, as it is certainly one of the greatest triumphs of engineering. The Great Indian Peninsular, and other lines, though inferior in length, are some of them, at least, of equal engineering interest.

With them may be classed the great roads, though the system like that of the railways, is still far from complete. The Grand Trunk Road from Calcutta to Lahore, 1300 miles in length, comprises every variety of construction, from the heavy gradients through the Rajmahal hills, to the massive and level embankments between the Jumna and Sutlej. The Lahore and Peshawur road, a continuation of the Trunk line, 270 miles long, and now rapidly approaching completion, may challenge comparison with any in the world; while, in the formidable extent of drainage crossed by it, it probably stands alone. Of others, the Hindostan and Thibet road, when finished, may take its place by the side of any of the famous Alpine roads; while the great Deccan road, the Assam road, and many others still in hand, are works of considerable magnitude.

Besides the length of the distances to be traversed, it is in the formidable character of the flood waters that have to be crossed that the specialities of their construction are to be sought. Nothing but actual experience will convince the English engineer of the enormous waterway required to pass drainage lines, which, seen only in the dry season, are so shallow and often perfectly dry; and scarcely a season passes without the most ample experience being set at naught by the results of some extraordinary flood. The Indus has been known to

rise 50 feet in a single night, where confined between its rocky banks at Attock. At a distance of 800 miles from its mouth, I have been in a boat in the middle, and was unable to descry either shore, while the deep channel in one single season has shifted its place laterally as much as three miles. Cross this river in the dry season, and the track lies over ten miles of quicksand and mud, while a channel of 1000 feet in width passes the whole body of water. To carry a road across the valley of such a river, and to bridge such a stream, may well daunt the boldest engineer.

This describes the rivers of Northern India only; those of Southern and Central India have also their peculiarities, which it would be tedious to detail here.

It is, however, in the great irrigation works that have been or are being constructed in India, that the peculiarities of Indian engineering are more especially to be sought; for, except in Italy, those works have no counterpart in Europe. The Ganges canal, 900 miles long with its branches, and pouring its waters over a million of acres through 3000 miles of distributing channels; the East and West Jumna canals, 200 and 500 miles long, respectfully; the Baree Doab canal, also 200 miles in length, are works of which any country may be proud, and in the principles and construction of which engineers have to learn much which they cannot be taught in England. An entirely separate class of works are the great weirs and tanks of Madras, whereof the works on the Godavery are the finest examples, and which are also purely Indian specialities.

Next, a word may be said as to Indian architecture. The architect and engineer are generally one, and he also is the constructor as well as designer. The requirements of the climate, necessitates modes of construction differing from those in England, but until lately we have not managed to combine coolness and ventilation with much architectural beauty. A reform in this respect is, however, in progress. We are at least erecting handsomer buildings, and attention is being directed towards cooling them effectually. The difficulties are great, for what does for the moist heat of the Lower Provinces, will not answer for the fierce dry heat of Upper India, which it is necessary to exclude for many months all day long, unless the air is artificially cooled before being admitted.* Moreover, the cold in the winter is often excessive, the average extreme range of the thermometer between summer and winter being fully 100 degrees in the Punjab, while in Bengal the temperature is much more equable, the range not exceeding 70°. With all these drawbacks, however, many fine public buildings have been completed, many more are being constructed and projected, and churches, railway stations, and government offices are rising fast, which would do no discredit to any capital.

Some specialities of construction which are common to most Indian buildings attract the attentions of the new comer. Except in the presidency towns, they have no upper story, partly from considerations

* The temperature of the air at midnight in Upper India during the months of May and June, is often over 100°.

of expense and partly because the upper rooms get very hot during the dry months. The roofs are either thatched or tiled, or else are flat and covered with brick and lime plaster. The thick beams supporting the roof are, as a rule, left exposed below, as ceiling cloths are apt to harbor vermin and conceal the depredations of white ants. The room walls are very rarely papered, being usually plastered and white-washed. Wooden floors would be too perishable and dear, so floors of flat tiles, or of lime plaster are substituted. Doors are numerous, and invariably double, opening in the middle. Verandahs all round a house are considered indispensable.

In many of the most important and interesting branches of engineering little has been done as yet in India; in drainage, water supply, and gas-lighting, we are now only making a commencement even in the presidency towns. A fine scheme, however, is in progress for the drainage of Calcutta, and a similar project will shortly be submitted for Madras, while the drainage and conservancy of native towns and European cantonments are engaging much attention.

In the improvement of our great rivers for inland navigation, little or nothing has been done, but many navigable canals are at work in Madras and Bengal, and others are in progress. In Bengal inundations from the sea and rivers have also given us practice in the important subject of embankments; and the Hidgelee sea dyke, when completed, will, it is said, be a noble work.

Of military engineering not much has to be said. Like the Romans of old, we encamp our troops in the open, instead of shutting them up in forts. Our arsenals are for the most part inside old native forts slightly improved, and, except Fort William and the outposts of our N. W. frontier, there is scarcely a single fort of modern construction in the country.

Closely allied as it is to engineering, a word must be said in praise of that noble work, the Indian Survey, of which too little is known to the scientific world. While the trigonometrical department is covering the country with a net-work of triangles, fixing the position of principal stations with an accuracy that has not been surpassed (if it has been equalled) in the European country,* the topographical department is busy in delineating the features of the mountain districts in a series of maps,† whose fidelity is only equalled by the difficulties which have attended their completion, and the revenue department is mapping the plains to a degree of detail which shows not only every village, but every field in each village.

Incomplete as this summary has been, I will hope that it may be useful in arousing some interest in England in the peculiarities of Indian engineering.

* The Superintendent G. T. Survey, Major Walker, has lately proceeded to Europe to confer with the Russian Government on the means of connecting the great series of Indian triangles with that of the Russian Survey.

† The map of Cashmere lately completed by Captain Montgomerie, R. E., has elicited the warm approval of the distinguished president of the Royal Geographical Society. Many of the trigonometrical stations were above the line of perpetual snow, where the surveyors had to stay for days together waiting for favorable weather for their observations.

MECHANICS, PHYSICS, AND CHEMISTRY.

On Weldless Tires, Circular Rolling, and Railway Wheels.

By Mr. F. J. BRAMWELL.

From the London Athenæum, September, 1865.

The writer gave an account of the mode of making tire hoops for railway wheels, prior to the invention of weldless tires, and pointed out that such mode consisted in bending a straight tire bar into a hooped form, the ends of the bar having been previously prepared, (if the weld were any other than a "butt" weld,) and then in uniting these ends together by welding, in one of the methods known as the "scarf" weld, or the "double V," or the "bird's mouth," or the "single V." Each one of these weld's required the operation to be performed when the tire was removed from the fire, and therefore not subjected to the full effect of the heat. All these methods were objectionable for other reasons; the "scarf" and the "bird's mouth" welds, because their edges were liable to be burnt; the "double" and "single V," because each required two lines to be made round instead of one. The "butt" weld, as it did not require any great preparation of the ends, admitted of the bar being delivered by the tire manufacturer in a hooped form, by which an economy was effected, inasmuch as the tire manufacturer bent the bar while hot from the rolling mill, and the weld was effected while the tire was actually in the fire, thus enabling the full advantage to be taken of the heat, and means were employed by which a clear surface was obtained, and only one line of weld had to be made sound. Though he (Mr. Bramwell) thought this form of weld the best, yet even that was a source of risk. The writer then proceeded to describe the process of "blocking" the welded tires, in order to stretch them to uniform sizes, as well as test their soundness, alluding to the operation of shrinking the tire on the wheel centre, either preceded or not by a boring process, the fastening on of the tire, and the completion of the wheel by turning the interior. The writer then proceeded to give a description of the mode in which, in the year 1844, he proposed to make tires without a joint weld, now known as weldless tires. This consisted in winding a long bar of iron into a helical coil, of very nearly the size and shape of the required finished tire hoop, and then in placing this coil in a circular furnace, having an opening or "gash" of the form of the sector of a circle, when seen on plan such sector subtending about 60° or 90°, and having placed within it a quick going mechanical hammer, provided with tools of nearly the shape of the finished tire, and adapted to operate on that portion of the hoop that lay out of the furnace and in the sector. By this means the writer proposed to weld the whole circumference of the coil by bringing welding hot portions successively out of the interior of the furnace in the sector-shaped gash. The writer proposed to finish off the ring forging thus made by means of the circular rolling machine which had been invented by Mr. Bodmer in the year 1839, and which, so far as the writer knew, was the first machine ever devised by which the continuous or "cir-

cular" rolling of a ring could be effected. The writer pointed out that Mr. Bodmer did not propose to make a weldless ring; but, on the contrary, intended to make that ring by welding together the ends of a bar, and that the object of his invention was to finish tires by rolling, instead of turning them in a lathe. The writer then stated that though, between the years 1844 and 1855, some few persons brought forward propositions for making weldless tires, nothing really was done, so far as he knew, between those dates in the way of manufacturing them. In the latter year, the writer made a proposition on the subject to Mr. W. Owen, of Rotherham, a large manufacturer of railway wheels, who, after a long consideration, commenced to make weldless tires in the year 1861. The Blaenavon Company commenced their manufacture about the same period. Prior to that time, viz: in 1856, the manufacture of these tires was commenced by Jackson, Petit, & Gauded, in France. Mr. Owen and the Limited Company who had succeeded him, had carried out the making of weldless tires to a very large extent, using machinery nearly the whole of which had been designed by the writer. At present, only very few mills were working upon the same plan, but several were preparing machinery for the purpose. The paper then described the process of making weldless tires, as adopted by the Owen Company. It consisted of making a helical coil of about half the diameter and three times the width of the intended tire, the heating of this coil in a furnace, and then putting it into a mould on the anvil of a steam hammer, and (by the action of the top tool upon it) welding it into a ring blank, about half the diameter and twice the thickness of the finished tire. The process is finished by the removal of this block to a circular rolling machine, on Bodmer's principle, but combined with hydraulic power of such character as to be capable of rolling out the tire to its proper decreased thickness and increased diameter. The paper then went on to show that not only is the manufacture of weldless hoops completed by circular rolling one that insures soundness and safety, but also, in consequence of dispensing with the "crop ends," and of the passing backwards and forwards of the bar whilst being rolled, both of which accompany and are drawbacks to ordinary rolling, such manufacture of weldless hoops is really an economical mode, and may be advantageously employed in the manufacture of all heavy straight bars, rails, and plates, which would in the first instance be rolled into the ring form, and then that ring being cut through would be got by flattening it out in the same way that sheets of glass were made by laying open the cylinder into which the glass was first formed. The paper pointed out how beneficial the use of weldless rings would be for boiler work, as they would dispense with the longitudinal seams, which were the source of weakness in boilers. The paper then described the improvement in manufacturing solid wrought iron wheel centres invented by M. Arbel, of France, and practiced by the Owen Company. It consisted of putting together the various parts forming the ring, spokes, and boss, and heating the same in a furnace, from which they were removed into a die, to be welded by the action of a powerful hammer, having (when its moving parts

were fitted so as to make the centres of engine wheels) a weight of more than twenty-five tons, and a maximum drop of six feet. The paper then described a common kind of wheel centre in very general use, wherein wrought iron spokes were combined with a cast iron boss, and pointed out the objection to this mode. It then stated the improvement of M. Lahousse, of Belgium, as practised by the Owen Company, by which the advantage of a wrought iron boss can be obtained at a rate as economical as that of a cast iron boss, and showed that this was done by enveloping cold or moderately heated wrought iron spokes in the highly plastic halves of a welding hot wrought boss, by which the spokes were firmly embraced and held fast. The paper concluded by expressing the conviction, on the part of the writer, that on account of the greater safety of weldless tires, they would come into universal use, and that, though the conservatism arising from the investment of capital in machinery, which would be displaced by a new invention, might delay its general adoption, the force of public opinion would, in the end, set aside the present process of manufacture, and lead to the adoption of that he described.

Mr. R. MALLET, described a process of producing the "butt" weld by rubbing the ends together, introduced some years ago, and asked why it was abandoned.

Mr. BRAMWELL believed that it was found impossible to adjust the motion and stop it exactly at the right instant required, as the temperature fell.

Mr. SIEMENS spoke in terms of approval of Mr. Bramwell's process. He said it seemed to open out a new field in the application of iron and steel. He thought, ultimately, makers would adopt the plan of rolling iron in a circular form and then opening it.

Sir. W. ARMSTRONG said that many important ideas had been brought before the meeting in Mr. Bramwell's paper, which, he had no doubt, would, in due time, be attended with very important results. As regarded the mode of manufacturing wrought iron rings, he looked with great favor on Mr. Bramwell's mode of constructing the weld by forming it first into a coil. It was a method which he (Sir W. Armstrong) had always advocated in the construction of guns; the advantage being that they got the welds into a longitudinal instead of a transverse direction.

On some Developments of and Improvements in Giffard's Injector.

By Mr. J. ROBINSON.

From the London Athenæum, September, 1865.

Having referred to the difference of opinion existing among engineers as to this, which had been called by the President, somewhat paradoxical instrument, the paper described the action of the injector to be as follows: Steam was taken from the steam space of any boiler by means of the injector, the water supply was brought into contact with the steam current, and the result in the shape of hot water was

passed into the water space of the boiler. The question was, now, having an equal pressure on all parts of the boiler, did a fluid not only pass in the shape of a current from one part to another, but at the same time carry with it another fluid exposed to atmospheric pressure only. The author propounded the following explanation of the instrument: Advantage is taken of the superior velocity at which a steam current issues from a boiler over that of a water current issuing from a boiler at the same pressure. These velocities are assumed to bear an exact proportion to the densities of the two fluids. The steam current, having but a small amount of momentum, the water supply is brought into contact with it, and two results follow: first, the steam current is incorporated with the water current by the condensation of the former; secondly, an amount of the velocity of the steam current is imparted to the water current in proportion of the quantities of each which are brought together in the combined jet. As the weight of steam issuing from an opening is exactly equal to the weight of water which would, under the like pressure, issue from the same opening in the same time, the area for the admission of steam to the injector is made greater than the area of the pipe which receives the condensed jet for transmission to the boiler, as otherwise the amount of the velocity imparted to the water current would not be sufficient to overcome the velocity of the resisting current from the boiler. The combination of the foregoing principles and arrangements in the injector is so effective that, with steam at a pressure of 30 lbs. above the atmosphere, water can be forced into a boiler containing steam of very nearly double that pressure. Having described the construction of the injector, the paper pointed out the importance of an apparatus capable of supplying water to steam boilers without motion of any of its parts, and independent of the engine connected with it. It has proved almost essential to some particular arrangements of boilers and engines. For locomotives, the advantage had been very considerable, inasmuch as it was most important that the machinery of engines running at such a high velocity should be free from the apparatus and repairs necessary when their boilers were fed by pumps worked by the engine. The advantage, also, was obtained of feeding the boiler while the locomotive was at rest, either in the station or during its retention in a siding, waiting for the line to be cleared. For this purpose, 5230 of the injectors had been manufactured in this country. For stationary boilers the injector had been found convenient, because of the saving of the pipes and other communication from the boiler to the engine room, the suppression of the pumps and the parts of the engine necessary to work them, and the advantage of being able to fill up the boilers during meal hours, and at other times when the engine was stopped. For this purpose, 3816 had been made in this country. For marine boilers the apparatus was most convenient, since it answered generally the purpose both of the main engine pumps and the donkey pumps, and brought the control of the feeding apparatus within the reach of the stokers, without reference to the engine room, and without the noise and complication of the donkey pump. In a simple form, and also in the ordinary injec-

tor arrangements, the principle had been applied for raising water from mines and wells, the inducement being the cheapness and simplicity of the apparatus, and the small space and easy manipulation required. The paper proceeded to describe in detail improvements which had been made upon the injector as it first came from the hand of the inventor; but these cannot be made clear without a reference to diagrams.

Mr. F. J. Bramwell said he would endeavor to explain the action of this apparently paradoxical instrument. He would ask the meeting to imagine two deep cisterns placed side by side, and with only a narrow space between them, and that in each near the bottom there was made an opening, these openings being exactly opposite the one to the other, and that one of the cisterns was filled with water while the other was empty, or, at all events, had not any water above the opening. In this condition of things, it was clear that a jet would issue from the opening in the side of the full cistern, would shoot across the narrow space between the two cisterns, and would enter the empty cistern at the aperture opposite to the one by which the jet had issued. Now, it was easy to believe that, not only might the jet enter if the receiving cistern were empty, but that it might even do so if the receiving cistern had water in it above the level of the opening so long as that were not so high (nor nearly so high) as that in the cistern from which the jet issued; and it appeared by experiment that if the water in the receiving cistern were not more than one-seventh of the height of that in the discharging cistern, the whole of the jet would be capable of entering the receiving cistern; and he (Mr. Bramwell) could well believe this, as he had found by actual experiment that when the water in the receiving cistern was one-half the height of that producing the jet, still 83 per cent. of all the water went in. He, therefore, thought the meeting might take it as established, that if there were a cistern containing 7 feet of water above an orifice in its side from which a jet issued, and that orifice were placed opposite and near to another orifice in the side of a cistern in which there was only one foot of water above this orifice, that the whole of the jet from the vessel containing 7 feet would run into and be received by the cistern containing the opposing amount of one foot depth of water. Let the meeting then imagine the cisterns having the same height of water in one as in the other, and he would ask them to imagine that a jet of water was issuing from the one, and was shooting across the space towards the other cistern; and he would ask them to assume that, by some magical means, that water was, in its passage across the space, converted into an equal weight (not an equal volume) of mercury. The result would be, in round numbers, that the jet when it reached the opposing cistern would be only one-fourth of the size of that which left the discharging cistern; so that a given weight of water, which issued from an orifice of fourteen square inches in the side of the discharging cistern, would (if it could in its passage across the space be converted into mercury) be capable of entering the receiving cistern through an orifice containing only one square inch. But if this could be accomplished, it would be mani-

fest there would be *concentrated* on one square inch the whole momentum which had issued from fourteen square inches; and, therefore, it was clear that if a concentration of seven times was sufficient to cause a jet to enter, a concentration of fourteen times was much more than sufficient. Of course, this assumption, that an issuing jet of water could be *concentrated* by being in its passage turned into mercury, was impossible; but, let the meeting consider the issuing jet to be that which it really was in the injector, viz: steam, and imagine this jet in its passage from the discharging orifice to the receiving orifice was condensed by an application of cold surfaces, then, indeed, there would be produced a concentration far greater than the fourteen times spoken of as taking place if the water were turned into mercury, and that would be the concentration due to the relation that equal weights of steam and water bore to each other. This, of course would vary according to the pressure of the steam, but it might be 1000 or more, or 800, or 400, or 200, according as the boiler from which the jet issued was working with low or high steam; but, even assuming the steam was so high that the concentration, when it was turned into water, was only 200 times; nevertheless, this would follow, that the jet of steam that required an opening of an area of 200 to escape from, would be capable, when condensed into water, of re-entering by an opening of an area of 1, and that, therefore, the concentration of force would be 200 times, and there could be no doubt whatever that this would be sufficient, and far more than sufficient, to enable the jet of steam that had issued from a boiler to return, in its condensed form, into that boiler. But if this were all that the apparatus could do, it was evident that it would be of no practical use; and he proceeded to explain how the instrument was capable of taking into the boiler other water along with that arising from the condensation of the steam. If the force were concentrated 200 times, it was, undoubtedly, much more than required. The issuing jet of steam was not merely condensed by an application of cold surfaces, but was, as is well known, condensed by suffering it to come in contact with a stream of the feed water; which, as it condensed the steam, became mixed with it so that the condensing water and the condensed steam flowed forward as one stream; but as this stream was now not merely composed of the water of the condensed steam, but also of that which condensed it, it followed that the degree of concentration was diminished, and, to an extent, depending on the amount of water which had been employed to condense the steam. If nine parts had been used, then the concentration, in lieu of being 200 times, would be twenty times, because the original one part and the nine together made ten parts in lieu of one, and therefore diminished the concentration to one-tenth of that which it was before, and if nineteen parts were used, then the concentration would only be ten times, and so on; it was self-evident that the water resulting from the condensation of the steam would possess so much surplus concentration, that it is clear it would be capable of taking with it several times its own weight of water before that concentration was reduced so far as to be unable to cause the jet to re-enter into the boiler or vessel from which it had proceeded.

At a recent discussion in London it had been stated the French engineers were of opinion that one-third of the entering jet must be uncondensed steam. He (Mr. Bramwell) believed this was an entire error, and he would ask the meeting to allow him to repeat to them an illustration which he had used at the meeting of the Mechanical Engineers, when Mr. Robinson first brought forward the subject there about six years ago, and that was to refer again to the cistern he had imagined, and to assume that there was in its side a valve opening inwards, but kept shut by the pressure of the water within, and that a person standing opposite to the cistern were to throw a steel bolt of a given weight with a certain velocity against the valve, it could readily be understood that the bolt might force open the valve and enter the cistern. Next, assume that an equal weight of steel were made into a spiral spring of the same diameter, but double the length of the bolt, and assume that this were thrown with a similar velocity to that used in the first instance against the valve, it might in this case also be understood that then, although there was the same weight of steel striking the valve with equal velocity, it might be unable to dash it open, because a large part of the momentum would be consumed in causing the spring to collapse, and thus the object of opening the valve might be frustrated. He (Mr. Bramwell) thought that this illustration showed how important it was that all the steam should be condensed, because steam being, as is well known, an elastic fluid, any uncondensed portion that formed part of the entering stream would act in the manner of the spring just mentioned, and, therefore, would be prejudicial to the efficient working of the injector.

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*On the Manufacture of Cast Steel, its Progress, and Employment as a Substitute for Wrought Iron.** By Henry Bessemer.

From the Civil Engineer and Architect's Journal, October, 1865.

On the 13th of August, 1856, the author had the honor of reading a paper before the Mechanical Section of the British Association at Cheltenham. This paper, entitled "The Manufacture of Malleable Iron and Steel without Fuel," was the first account that appeared, shadowing forth the important manufacture now generally known as the Bessemer process.

It was only through the earnest solicitation of Mr. George Rennie, the then President of the Mechanical Section of this Association, that the invention was at that early stage of its development, thus prominently brought forward; and when the author reflects on the amount of labor and the expenditure of time and money that were found to be still necessary before any commercial results from the working of the process were obtained, he has no doubt whatever but that, if the paper at Cheltenham had not then been read, the important system of manufacture to which it gave rise, would to this hour have been wholly unknown.

In the original fixed converting vessel, as patented and erected in

* Read before the British Association.

London for experimental purposes in 1856, the tuyeres were passed through the side of the vessel in a horizontal direction. The result was, that the blast of air entered only a short distance into the fluid mass, and much of it escaped upwards between the sides of the vessel and the metal. The effect of this was the rapid destruction of the brick lining, caused by the excessive temperature generated in the process, and the solvent property of the resulting silicate of protoxide of iron, which sometimes destroyed a lining of half a brick in thickness during the blowing of two charges of metal for about twenty minutes each. Another difficulty arose from the impossibility of stopping the process without running out the metal, for if the blowing ceased for one instant, the fluid metal would run into the tuyeres, and stop them up.

A great inconvenience of the fixed vessel also arose from the danger and difficulty in tapping out the fluid malleable iron with a bar, after the manner of tapping an ordinary cupola furnace, for the blast had to be continued during the whole time the charge was running out of the vessel, in order to prevent the remaining portions from entering the tuyeres. A similar difficulty arose while running in the crude metal from the melting furnace, since it was necessary to turn on the blast before any metal was run into the vessel, the first portions so run in were, in consequence, partially decarbonized before the whole of the crude metal had left the melting furnace.

These were among the most prominent difficulties that had to be remedied. It is, however, satisfactory to know that even in this, its infant state, the process and apparatus were practically successful, in proof of which there is placed upon the table part of a malleable iron railway bar made from pig iron, at Baxter House, by blowing air through it in the apparatus just described, the fluid malleable iron having been run into a 10 inch square ingot mould, and the bloom so made rolled direct into the bar shown. The small malleable iron forged gun will serve as an example of the clearness and freedom from cracks or flaws in malleable iron, so made and forged under the steam hammer. It is one of the very early productions of the process, and, like the malleable iron rail, was made wholly without any recarbonizing of the metal, or the employment of spiegeleisen or manganese in any form whatever. Malleable iron so made from hematite pig iron is red-short, like all other wrought iron made wholly from hematite; but that it is perfectly malleable and extremely tough when cold may be seen on examination of the iron rope exhibited, which consists of four rods of $1\frac{1}{2}$ inch round iron twisted cold into a close coil. These bars extended 13 inches in length in 4 feet, and were reduced nearly $\frac{1}{8}$ inch in diameter, in the operation of twisting, thus showing that malleable iron so made possesses an extraordinary degree of ductility.

It may be remembered that an important part of the process, as described at Cheltenham in 1856, consisted in tapping the fluid crude iron from the blast furnace, and allowing it to flow direct into the converting vessel, and be there blown to the extent only of decarbonizing it so far as to produce cast steel. This part of the original programme has been most successfully carried out in Sweden, where an extensive

establishment for its manufacture has been erected by M. Göranson, of Geffle. The large steel circular saw plate exhibited, is an example of the conversion of crude cast iron run direct from the blast furnace into the converting vessel, and there blown for nine minutes, in which period it had been converted into cast steel of the desired quality, and was then placed into an ingot mould without being recarbonized, and wholly without the employment of spiegeleisen or manganese in any form whatever.

With these few illustrations of capabilities of the process as originally described at Cheltenham, the author will proceed to show how the disadvantages of the old fixed converting vessel were remedied and other improvements introduced. Many forms of converting vessels were tried on the large scale before this desirable object was attained. In some of them the lining was too easily broken down by the violent motion of so heavy a fluid as iron; in some of the forms tried, the angles allowed the metal to solidify them, and so clog up the vessel; in others, the mouth of the vessel being too small, caused the metal to be thrown out by the force of the escaping blast. It was also found that if the mouth was too large the heat escaped, so as to cause part of the converted metal to solidify in the vessel; the relative height and diameter of the vessel was also found to produce important differences in the working of the process; finally, and after many long and expensive trials, the form of vessel shown at B and C was adopted.* This vessel is made in two parts, so as to admit easily of its being lined up with a pulverized silicious stone, known as "ganister," which so resists the action of the heat and slags as to last for fully 100 consecutive charges of steel before it is worn out. Its form is that of the arch in every position which prevents the lining from falling down by its own weight. There are no angles in which the splashes of metal can solidify and accumulate. Its mouth directs the flame and sparks away from the workmen, and from the moulds and other apparatus; while the throat of the vessel, and the position of the mouth, almost entirely prevents the throwing out of the metal. The vessel is mounted on trunions supported on stout pedestals, so that a semi-rotary motion may be communicated to it at pleasure. The tuyeres are placed at the bottom of the vessel, so as to force the air vertically upward through the metal, as shown, without coming in contact with the sides of the vessel. When the crude metal is to be run into the vessel it is turned on its axis nearly into the position shown at C, the mouth being a little higher up; a gutter will then conduct the crude cast iron from the melting furnace into it. It is not necessary to turn on the blast until the whole of the metal is run in, because the tuyeres occupy a position above the level of it. As soon as the air is admitted through the tuyere, the vessel is turned into the position shown at B, when its decarbonization immediately commences. As soon as this is effected as much molten pig iron made from spathose iron ore is added to it as will restore the quantity of carbon necessary to produce the desired quality of steel, which is then run into the casting ladle in the manner shown,

* See the Journal, vol. xxiv., p. 179.

and from whence it is transferred to a series of iron moulds ranged in a semi-circular pit, each mould being placed within the sweep of the casting crane; the filling of these moulds is regulated by a cone valve made of fire clay, and fitted in the bottom of the casting ladle, so as to be opened or shut at pleasure by means of a handle on the outside of the ladle.

It will be readily understood that in the fixed vessel first described any giving way of a fire clay tuyere would stop the process, and cause much inconvenience; but with the movable vessel it is not so, for at any moment of time during the process the vessel may be turned on its axis and the tuyeres raised above the level of the metal; the blast may then be turned off, the tuyere box opened, and the faulty tuyere stopped up or removed, after which the process may be again resumed. The movement of the vessel on its axis, the rise and fall of the casting crane, and the other cranes employed for removing ingots from the casting pit, are all effected by a simple hydraulic apparatus, so that the whole process is under the perfect control of a single operator, placed far away from the heat and showers of splashes that accompany the process.

Up to this period the manufacture of cast steel by the old, as well as the new process, is still so far imperfect that steel of the highest quality cannot be made from inferior iron. In the old Sheffield process the original quality of the Swedish charcoal iron employed governs the quality of the cast steel made; consequently, £36 per ton is freely given for the high class Danamora iron, while other brands of Swedish charcoal iron may be bought for £15. In either case these are expensive raw materials for the cast steel maker.

In 1839, the trade of Sheffield received an enormous impulse from the invention of Josiah Marshall Heath, who patented in this country the employment of metallic manganese, or, as he called it, carburet of manganese. The addition of a small quantity of this metal, say from one-half to one per cent., rendered the inferior coke made irons of this country available for making cast steel; it removed from these inferior qualities of iron their red-shortness, and conferred on the cast steel so made, the property of welding and working soundly under the hammer. This invention was of immense importance to the town of Sheffield, where its value was at once appreciated. Mr. Heath, supposing himself secure in his patent, told his licenses that if they put oxide of manganese and coal tar, or other carbonaceous matter, into their crucibles along with the blister steel, that it would do as well and be much cheaper than the carburet of manganese he was selling them; in effect it was the same thing, for before the steel was melted, the carbon present reduced the manganese to the metallic state, so that his patent carburet of manganese was formed in the crucible in readiness to unite with the steel as soon as it became perfectly fused. But the law decided that this was not Heath's patent, and so the good people of Sheffield, after many years of litigation, were allowed to use it without remuneration to the inventor.

Manganese has now been used for many years in every cast steel

works in Europe. It matters not how cast steel is made, since manganese added to it necessarily produces the same beneficial changes; no one better appreciated this fact than the unfortunate Mr. Heath, as evidenced by his patent of 1839, in which he declares that his invention consists in "the use of carburet of manganese in any process whereby iron is converted into cast steel." Had Heath seen in his own day the Bessemer process in operation, he could not have said more; he well knew the effect produced by manganese on steel, and, therefore, claimed its employment in any process whereby iron is converted into cast steel.

With this patent of Heath's expired and become public property, coupled with the universal addition of manganese and carbon to cast steel, it would naturally be supposed that the author, in common with the rest of mankind, would have been allowed to share the benefits which Heath's invention had conferred on the whole community, but it was not so.

The reading of the author's paper at Cheltenham in 1856, was, by the powerful agency of the press, communicated in a few days to the whole country. Great expectations of the value of the new process formed, both by scientific and practical men, in proof of which it may be stated that licenses to manufacture malleable iron under the patent were purchased by iron masters to the extent of £25,000 in less than twenty-five days from the reading of the Cheltenham paper. Great excitement existed at that moment in the iron trade, and many persons seemed to covet a share in an invention that promised so much; there was, consequently, a general rush to the patent office, each one intent on securing his supposed improvement. It was thought scarcely possible that the original inventor should, at the very outset, have secured in his patents all that was necessary to the success of so entirely novel a system, he must surely have overlooked or forgotten something; perhaps even left out all mention of some ordinary appliance too well understood to really need mentioning; so in the jostle and hurry to secure something, any point on which a future claim could be reared, was at once patented. Some of these gentlemen even re-patented portions of the writer's own patents, while others, patented things in daily use, in the hope that they might be considered new when added to the products of the new process.

Within six weeks of the date of the Cheltenham paper, Mr. Robert Mushet had taken out three patents, which form part of that long series of patents by which he hoped to secure to himself the sole right to employ manganese in combination with iron or steel made from pig iron, by forcing atmospheric air through it. In this long series of patents almost every conceivable mode of introducing manganese into the metal is sought to be secured. It was claimed if used in combination with pitch, or other carbonaceous matter; it was claimed if simply used in the metallic form, or, as Mr. Heath calls it, a carburet of manganese; it was also claimed if combined with iron and carbon—as in spiegeleisen. Manganese, in any of these states of combination, was claimed if put in with the metal prior to the commencement of the

process; it was claimed if put in during the continuation of the process, and claimed if added to the steel after the process had been completed; it was also claimed if put into any furnace, crucible, or vessel, that the converted metal might be run or poured into; in fact, manganese and its compounds were so claimed under all imaginable conditions, that if this series of patents could have been sustained in law it would have been utterly impossible for the author to have employed manganese with steel made by his process, although it was considered by the trade to be impossibe to make steel from a coke-made iron without it.

In the *Mining Journal*, of September 24th, 1853, just four years before the first of Mr. Mushet's series of patents, a letter was published on the subject of Heath's invention. The writer of that letter says: "I am a steel maker, and deny that steel was ever made with the addition of carbon and manganese or carburet of manganese previously to Heath's invention, and I confidentally assert that no cast steel maker can now carry on his business to profit without the aid of carburet of manganese." "There are," he says, "a hundred methods of improving steel with manganese, but they all involve the same principle. Put carbon and manganese into the steel pot in any form you please, and at any time you like, and if the steel be thoroughly melted the carburet of manganese melts also and is alloyed, and the improvement is unerringly effected, and by the use, in every instance, of carburet of manganese."

This letter clearly shows how well the subject was understood in the steel trade thirteen years ago.

Very soon after the reading of the Cheltenham papers, several rough trials of the Bessemer process were made privately by persons in the iron trade, and defects discovered which were supposed by practical men to be perfectly fatal to the invention. Once more the press teemed with accounts of the process, but this time it spoke only of its utter impracticability, and of regrets that the expectations originally formed were so fallacious. The storm, however, gradually subsided, and the process and its author were soon entirely forgotten. Imperfections in the process there certainly were, but the author had had the most irrefragable proofs of the correctness of the theory on which his invention was based, and also that the reasoning on which it was so utterly condemned by the trade was in itself wholly fallacious; he, therefore, decided not to argue the question against a hundred pens, but to energetically prosecute his experiments, and to remain silent until he could bring the process to a commercial success. When, at the expiration of about three years of incessant labor on the part of himself and partner, Mr. Longsdon, and an expenditure of more than £10,000, the process was again brought before the public, not the slightest interest was manifested by the trade; it had been for years agreed on all sides that it was a total failure, and was looked upon simply as a brilliant meteor that had suddenly flitted across the scientific horizon, leaving the subject in more palpable darkness than before. This entire want of confidence on the part of the trade was most discouraging;

one of two things became imperative, either the invention must be abandoned, or the writer must become a steel manufacturer; the latter alternative was unhesitatingly accepted, and Messrs. Henry Bessemer & Co. determined to erect a steel works at Sheffield, in the very heart of that stronghold of steel making. At these works the process has ever since been successfully carried on; it has become a school where dozens of practical steel makers received their first lessons in the new art, and is the germ from which the process has spread into every state in Europe, as well as to India and America.

By the time the new works at Sheffield had got into practical operation, the invention had sunk so low in public estimation that it was not thought worth paying the £50 stamp due at the expiration of three years on Mr. Mushet's large batch of manganese patents; they were, consequently, allowed to lapse and become public property.

The author has, therefore, used without scruple, any of these numerous patents for manganese, without feeling an overwhelming sense of obligation to the patentee.

At the suggestion of the author, a works for the production of manganese alloys was erected by Mr. Henderson, at Glasgow, who now makes a very pure alloy of iron and manganese, containing from twenty-five to thirty per cent. of the latter metal, and possessing many advantages over spiegeleisen, which it will doubtless replace. Two bright rods of $1\frac{1}{8}$-inch in diameter will be found on the table. They were folded up cold under the hammer. This extremely tough metal is made by using Mr. Henderson's alloy in lieu of spiegeleisen, which is incapable of making steel of such a quality.

A Prussian gentleman, M. Preiger, has been also successful in manufacturing a new alloy, which he calls ferro-manganese, consisting of sixty to eighty per cent. of metallic manganese. It is extremely useful in making malleable iron by the Bessemer process in which spiegeliesen cannot be employed on account of the large proportion of carbon it contains.

It is gratifying to turn from a review of the troubles and impediments of the past, and briefly notice some of the more important applications of steel as a substitute for wrought iron.

In no case is this change of material more important than in the construction of ships, for in no instance are strength and lightness more essential.

The Bessemer cast steel made for ships' plates by the several eminent firms now engaged in that manufacture, is of an extremely tough and ductile quality, while it possesses a degree of strength about double that of the inferior kind of iron plates usually employed in shipbuilding, hence it is found that a much less weight of material may be employed, and at the same time, a greater degree of strength may be given to all parts subjected to heavy strains.

Most prominent among the builders of steel ships, is the firm of Jones, Quiggin, & Co., of Liverpool, who have now constructed no less than 31,510 tons of shipping wholly or partially built of steel. Of these, thirty-eight vessels are propelled by steam with an aggregate

of 5910 horse power; besides this the principal masts and spars of eighteen sailing ships have been made by them wholly of steel.

Vessels of a large size, constructed to class A A twelve years at Lloyd's, weigh, when built of iron, about 12 cwt. per ton measurement; whereas, similar vessels built of steel weigh only about 7 cwt. per ton measurement; thus an iron ship, to take first class at Lloyd's for 1000 tons measurement, would weigh 250 tons more than a steel one of the same class. Such a vessel could, therefore, take 250 tons, or 25 per cent. more freight at the same cost, or could avail herself of the difference of immersion to leave or enter port when the tide would not permit an iron vessel to do so. As a steamer she would carry 250 more tons of coal, and thus be enabled to lengthen her voyage or take her coal for the return trip. The two steel paddle wheel steamers launched at Liverpool, by Messrs. Jones & Co., on the 13th ult., for Dublin and Liverpool service, will draw from 3 ft. to 4 ft. less water than iron steamers built on the same lines, and being thus enabled to leave port at all states of the tide, will not require a tidal train in connexion with them. If the employment of steel for the construction of merchant vessels is found to be so important, how much more is it for ships of war. Some of the larger class of armor-plated vessels require 6000 tons of iron for their construction, and an addition of 1800 tons in the shape of $4\frac{1}{2}$-inch armor plates. Now, if the frames and inner skin of such a vessel were constructed of steel, it would be much stronger even if reduced to 4000 tons in weight; this would admit of 9-inch armor plates being used in lieu of $4\frac{1}{2}$-inch, and would still leave the vessel 200 tons lighter than the present ones; and hence, as the resistance of the armor to impact is as the square of the thickness of the plate, we should have a vessel capable of resisting four times the force of those at present constructed, while it would be 200 tons less in weight.

These important facts have not escaped the attention of Mr. Reid, our present talented constructor of the navy, and we shall, doubtless, soon have substantial proof of what may be effected by the employment of steel in the construction of ships of war.

The application of steel for projectiles has now become a necessity since the introduction of armor plates. We have before us a 110 lb. shot, that has passed, with very slight injury, through a 5-inch armor plate, and also some specimens of bent angle iron, made of Bessemer iron, and rolled at the Millwall Iron works in London, and from the same works a portion of one of Hughes' patent hollow steel beams for supporting the armor plating in course of construction for the forts at Cronstadt; both these are interesting examples of what the rolling mills of the present day can effect, and of the facility with which cast malleable iron and cast steel admit of being worked into the most difficult forms.

There is no department in engineering in which the peculiar toughness of steel, and its strength and power of resisting wear and abrasion, are of such vital importance as in its application to railway purposes. This fact had long since impressed itself strongly on the mind of Mr. Ramsbottom, of the London and North Western Railway, who commenced experiments with this material in 1861; carefully, though

trustingly, he tried it step by step, not even at first venturing to employ it for passenger trains, but as proofs of its safety and economy crowded upon him, he carefully applied it to the most important parts of passenger engines, and even to the manufacture of the formidable engine cranks, (at that time entrusted only to the most eminent iron making firms of the kingdom.) These iron cranks are now being replaced by steel ones forged from a single mass. One of these steel cranks, manufactured at the new steel works at Crewe, has been obligingly lent by Mr. Ramsbottom as an illustration of the use of steel for this purpose; that gentleman has also taken out of use a plain steel axle that has run a distance of 112,516 miles and now exhibits very slight signs of wear.

The tires of wheels, on which so much of the public safety depends, were then tried, but the exact amount of difference between the endurance of wrought iron and Bessemer steel for this purpose is not yet ascertained, as none of these steel tires are yet worn out; but enough has been shown to prove the advantage of entirely replacing iron by steel for this purpose.

In order to show how a steel tire will resist the most violent attempts to produce fracture, an example is given of a steel tire manufactured by Messrs. Bessemer & Co., of Sheffield; it was placed on edge under a six-ton steam hammer, and subjected to a series of powerful blows until it assumed its present form, that of a figure 8, a degree of violence immensely more than it could ever be subjected to in practice. These tires are made without weld or joint, by forging them from a square ingot, partly under the improved plan invented by Mr. Ramsbottom, and partly by an improved mode of flanging and rolling, invented by Mr. Allen, of the Bessemer Steel Works, Sheffield.

So important were found to be the advantages of employing cast steel as a substitute for wrought iron at the works of the London and North Western Railway Company, that the directors, acting under the advice of their able engineer, determined on building a large steel works at Crewe, which is now in active and successful operation. In the design and arrangement of their plant for working up the steel, several important improvements have been introduced by Mr. Ramsbottom, among others his duplex hammer, which strikes a bloom on both sides of the ingot at once, in a horizontal direction, and thus renders unnecessary the enormous foundations required for ordinary hammers. Here also he has put up his improved rolling mill for rolling blooms of large size, the enormous machine being reversed with the greatest rapidity and ease by the attendant, without any shock or concussion whatever.

While matters were thus steadily progressing in the engine department of the company, the engineer of the permanent way, Mr. Woodhouse, took in hand a thorough investigation of a no less important problem, viz: the substitution of cast steel for wrought iron railway bars. For this purpose some 500 tons of rails were made, and put down at various stations where the traffic was considerable, so as to arrive, at the earliest period, at a true comparison of the respective endurance of wrought

iron and cast steel rails. It will be unnecessary here to enter into the numerous details of the extensive series of experiments systematically carried out by Mr. Woodhouse; the trials made at Camden will suffice to show the extraordinary endurance of steel rails. It is supposed that there is not one spot on any railway in Europe where the amount of traffic equals that at the Chalkfarm bridge at Camden town. At this spot there is a narrow throat in the line, from which converges the whole system of rails employed at the London termini of this great railway. Here all passengers, goods, and coal traffic have to pass; here, also, the making up of trains and shunting of carriages is continually going on. At this particular spot two steel rails were fixed on May 2, 1862, on one side of the line, and two new iron rails were on the same day placed precisely opposite to them, so that no engine or carriage would pass over the iron rails without passing over the steel ones also. When the iron rails became too much worn to be any longer safe for the passage of trains, they were turned the other way upwards, and when the second side of the rails were worn as far as the safety of the traffic would allow, the worn out rail was replaced by a new iron one—the same process being repeated as often as was found necessary. Thus we find, at the date of the last report, on March 1, 1865, that seven rails had been entirely worn out on both faces. Since then another has been worn out up to July, making sixteen faces worn out, the seventeenth face being in use on August 22, when the steel rail that had been placed opposite to them was taken up in the presence of the writer, and, by the kind permission of Mr. Woodhouse, now lies on the table before the meeting. The first face of the rail only has been used, and this is now become much thinner than it was originally, but, in the opinion of the plate-layers, is still capable of wearing out another half dozen faces. Taking its resisting powers at three more faces only, it will show an endurance of twenty to one in favor of steel.

Mr. Woodhouse has ascertained, by careful and continued testing for twenty-four hours at a time, that an average of 8082 engines, tenders, or carriages, pass over the steel rails every twenty-four hours, equal to 16,164 wheels every day for 1207 days, making a total of 9,754,974 wheels passed over the rail. Subject to this excessive wear the rail appears to have been reduced 7½ lbs per yard, hence for every grain in weight of steel lost by abrasion, no less than 371 wheels had to pass over it. Another steel rail, put down also in May, 1862, at a place much less subject to wear, has had four faces of iron rails worn out opposite to it, and still appears as if very little used; this rail is also placed on the table. An iron rail wears out by the giving way at various parts of the imperfectly welded mass, and not by the gradual loss of particles of metal, as in the case of the steel rail, which no amount of wear and tear seems capable of disjointing. It must be borne in mind that this enormous endurance of cast steel is not owing to its hardness and brittleness, as some have supposed, for, in fact, Bessemer steel possesses an extreme degree of toughness. There is before the meeting an example of this fact: one of the same quality of steel rails

having been attached at one end to the main driving shaft of a steam engine, so as to twist it while cold, into a long spiral, measuring nine feet in length at top and bottom, and only six feet if measured along the centre of the web. A single glance at this spiral rail will, it is presumed, dispel any idea of brittleness that may have been entertained.

In conclusion, it may be remarked that cast steel is now being used as a substitute for iron to a great and rapidly increasing extent.

The jury reports of the International Exhibition of 1851, show that the entire production of steel of all kinds in Sheffield was, at that period, 35,000 tons annually, of which about 18,000 tons were cast steel, equal to 346 tons per week; a few other small cast steel works in the country would probably bring up this quantity to 400 tons per week, as the entire production of cast steel in Great Britain. The jury report also states that an ingot of steel, called the "monster ingot," weighing 24 cwt., was exhibited by Messrs. Turton, and was supposed to be the largest mass of steel ever manufactured in England. Since that date a great change has been made, for the largest Bessemer apparatus at present erected at Sheffield, at the works of Messrs. John Brown & Co., is capable of producing with ease every four hours a mass of cast steel weighing 24 tons, being twenty times larger than the "monster ingot" of 1851.

There are now seventeen extensive Bessemer steel works in Great Britain. At the works of the Barrow Steel Company 1200 tons per week of finished steel can easily be turned out, and when their new converting house containing twelve more five-ton converters is completed, these magnificent works will be capable of producing weekly from 2000 to 2400 tons of cast steel. There are at present erected, and in course of erection, in England, no less than sixty converting vessels each capable of producing from three to ten tons at a single charge. When in regular operation, these vessels are capable of producing fully 6000 tons of steel weekly, or equal to fifteen times the entire production of cast steel in Great Britain before the introduction of the Bessemer process. The average selling price of this steel is at least £20 per ton below the average price at which cast steel was sold at the period mentioned. With the present means of production, therefore, a saving of no less than £6,240,000 per annum may be effected in Great Britain alone, even in this infant state of the Bessemer steel manufacture.

On Chemistry Applied to the Arts. By Dr. F. Crace Calvert, F.R.S., F.C.S.

From the London Chemical News, No. 248.

(Continued from page 341.)

Lecture V.

Milk, its composition, properties, falsification, and preservation. *Urine*, its uses. A few words on putrefaction.

Milk.—The composition of this important fluid varies, not only in different classes of animals, but also in different individuals of the same

class. Further, the composition of milk is modified by the influence of food, climate, degree of activity, and health. Notwithstanding these variations, an average can be arrived at by numerous analyses, and the following table will give a general idea of milk:

	Woman's.	Cow's.	Ass'.	Goat's.	Ewe's.
Dried caseine, .	15·2	44·8	18·2	40·2	45·8
Butter, . .	33·5	31·3	1·1	33·2	12·0
Sugar of milk, .	65·0	47·7	60·8	52·8	50·0
Salts, . .	4·5	6·0	3·4	5·8	6·8
Water, . .	881·8	870·2	916·5	868·0	885·4
	1000·0	1000·0	1000·0	1000·0	1000·0

The various substances comprised in milk may be classified under three heads: cream, curd or caseine, and whey.

Cream, according to Dr. Voelcker's* analysis, is composed of

Water, . . .	61·67	64·80
Butter, . . .	33·43	25·40
Caseine, . . .	2·62 }	7·61
Sugar of milk, . .	1·56 }	
Mineral matters, .	0·72	2·19
	100·00	100·00

And may be considered as consisting of small, round, egg-shaped globules, composed of fatty matters, enclosed in a thin cell of caseine, which, being lighter than the fluid containing them, rise to the surface and constitute cream, and in proportion to the quantity of this removed from the milk, the latter becomes less opaque, and assumes a blue tinge. When exposed to the air for a short time in a dry place it loses water, becomes more compact, and constitutes what is called cream cheese. When churned, cream undergoes a complete change; the caseine cells are broken, and the fatty globules gradually adhere one to the other and form a solid fatty mass, called butter, and it is found, on an average, that 28 lbs. of milk will yield 1 lb. of butter. Fresh butter is composed of

Fatty matters, ...	Margarine, Oleine, Caproine, Caprine, Butyrene, Caproleine,	77·5
Caseine, ...		1·6
Whey, ...		20·9
		100·0

* For further particulars on this subject, the reader is referred to Dr. Voelcker's paper, published in the *Journal of the Royal Agricultural Society of England*, volume xxiv.

But, as butter rapidly becomes rancid, it is necessary to adopt means to prevent this as much as possible, and the following are the usual methods, viz: working the butter well with water, and then adding 3 or 4 per cent. of common salt, or melting the butter at a temperature below 212°; but the following method, employed by M. Bréon, appears to give general satisfaction: It consists in adding to the butter water containing 0.003 of acetic or tartaric acid, and carefully closing the vessels containing it. The rancidity of butter is due to a fermentation generated by the caseine existing in it, which unfolds the fatty matters into their respective acids and glycerine, and as the volatile acids, butyric, caproic, &c., have a most disagreeable taste and odor, it is these which impart to butter the rank taste. Allow me to add, *en passant*, that whilst butyric acid possesses a repulsive smell, its ether has a most fragrant odor, viz: that of pineapple, for which it is sold in commerce.

Curd of Milk, or Caseine, has, according to Dr. Voelcker, the following composition:

Carbon,	53·57
Hydrogen,	7·14
Nitrogen,	15·41
Oxygen,	22·03
Sulphur,	1·11
Phosphorus,	0·74
	100·00

And is easily recognizable by its white flocculent appearance. It is insipid and inodorous, like albumen, from which it differs in its insolubility in water, though it is dissolved by a weak solution of alkali or acid. But what chiefly distinguishes caseine is, that it is not coagulated on boiling, and that rennet precipitates it from its solutions. Dr. Voelcker has proved, however, in his researches on cheese, that the commonly received opinion that rennet coagulates milk by decomposing the lactine into lactic acid is incorrect, for he has coagulated milk while in an alkaline condition, and it is owing to the difference in the action of rennet on albumen and caseine that chemists have been able to detect the presence of ½ to ¾ per cent. of albumen in milk. This important organic substance not only exists in milk, but is also found in small quantities in the blood of some animals, such as the ox, and in a large class of plants, but more especially in the leguminous tribe, such as peas, beans, &c. Caseine is the basis of all cheeses, and when these are made with milk from which the cream has been previously taken, the cheese is dry, but when part of the cream has been left, the cheese is rich in fatty matters as well as in caseine; and I may add that the peculiar flavors characterising different cheeses are caused by modifying the conditions of the fermentations which the organic matters undergo. The following researches made by M. Blondeau illustrate this point, as well as the modifications which cryptogamic life, under peculiar circumstances, may effect in the composition of organic substances, and his interesting results were obtained in studying the

conversion of curd into the well known cheese of Roquefort. He placed in a cellar some curd of the following composition:

Caseine,	85·43
Fatty matters,	1·85
Lactic acid,	0·88
Water,	11·84
	100·00

To which he added a small quantity of salt. After a month, and again after two months, he analysed portions of the same, with the following results:

	After one month.	After two months.
Caseine,	61·33	43·28
Fatty matters,	16·12	32·31
Chloride of sodium,	4·40	4·45
Water,	18·15	19·16
Butyric acid,	. .	0·67
	100·00	99·87

The above figures show a most extraordinary change in the caseine or curd, for we observed that the proportion of caseine gradually decreases, and is replaced by fatty matters. Considering the circumstances under which this phenomenon has occurred, there can be no doubt that this curious conversion of an animal matter into a fatty one is due to a cryptogamic vegetation or ferment; and if the Roquefort cheese be exposed to the air under a bell jar for twelve months, the decomposition becomes still more complete; for it is no longer the caseine which undergoes a transformation, but the oleine of the fatty matters. The following analyses clearly illustrate this curious action. Composition of the cheese after two and twelve months:

	After two months.	After twelve months.
Caseine,	43·28	40·23
Margarine,	18·30	16·85
Oleine,	14·00	1·48
Butyric acid,	0·67	. .
Common salt,	4·45	4·45
Water,	19·30	15·16
Butyrate of ammonia,	. .	5·62
Caproate of "	. .	7·31
Carprylate of "	. .	4·18
Caprate of "	. .	4·21
	100·00	99·49

The substances to which cheeses owe their peculiar flavor are ammoniacal salts, chiefly composed of various organic acids, such as acetic, butyric, capric, caproic, and caproleic. I cannot better conclude my remarks on cheese than by extracting from Dr. Voelcker's interesting papers a few of his analyses of different kinds of cheese:

	Cheshire.	Stilton.	Old Cheddar.	Double Glo'ster.	Single Glo'ster.	American.
Water, . .	32·59	20·27	30·32	32·44	28·10	27·29
Butter, . .	32·51	43·98	35 53	30·17	33·68	35·41
†Caseine, . .	26·06	}	28·18	31·75	30·31	25·87
Sugar of milk, }	4·53	{33·55}	1·66	1·22	3 72	6·21
Lactic acid, }		}				
†Mineral matter,	4·31	2·20	4·31	4·42	4·19	5·22
	100 00	100·00	100·00	100·00	100·00	100·00
†Nitrogen, .	4·17	3·89	4·51	5·12	4·85	4·14
†Common salt, .	1·59	0·29	1·55	1·41	1·12	1·97

The principal applications of caseine in arts and manufactures is that first introduced by Mr. R. T. Pattison, who used it, under the name of lactarine, for fixing pigments in calico printing. His process consists in drying the washed curds of milk, which he sells to the calico printer, who mixes it with a solution of ammonia or weak alkali, which swells it out and renders it soluble in water. To a solution of this substance, of proper consistency, he adds one of the tar colors, prints it, submits the goods to the action of steam, which drives off the ammonia, leaving fixed on the fabric the caseine and color. In consequence of the insoluble compound which caseine forms with lime, it has often been used as a substitute for glue or linseed oil in house painting, and it may be useful to some of my audience to know that when caseine is dissolved in a concentrated solution of borax, an adhesive fluid is formed, which is capable, in many cases, of serving the purposes of glue or starch. Mr. Wagner has made another useful application of caseine, mixing it with six parts of calcined magnesia, and one part of oxide of zinc, and a sufficient quantity of water to make a pasty mass, which he leaves to solidify, and when dry it is extremely hard, susceptible of receiving a high polish, and is sold as a substitute for meerschaum.

Whey.—According to Dr. Voelcker, the composition of whey is as follows:

Water, ...	89·65
Butter, ...	0·79
Caseine, ...	3·01
Sugar of milk, ...	5·72
Mineral matters, ...	0·83
	100·00

When whey is concentrated to the state of syrup, and kept in a cold place, it gradually deposits fine, well defined crystals, which, on further purification and re-crystallization, yield white quadrangular prisms of a substance called lactine, or sugar of milk, which is highly interesting. It is remarkable that, while sugar of milk has only been known in Europe for a comparatively short period, where homœopathists are its principal

employers, in India lacthine has been known for a great number of years. Let us now study some of the chemical facts connected with the history of sugar of milk. Thus, cane sugar, when acted upon by nitric acid, gives oxalic acid, whilst lactine gives mucic acid. Cane sugar, when unfolded under the influence of a ferment, gives alcohol and carbonic acid; lactine yields lactic acid. As the latter transformation is most important, in a physiological and chemical point of view, allow me to dwell upon it for a few minutes. The substance which possesses the property of most readily converting lactine into lactic acid is caseine after it has undergone some peculiar modification, which renders it a ferment. Thus, when milk leaves the cow it is alkaline, but when exposed to the air it rapidly becomes acid, and this is due to the conversion of lactine into lactic acid, a change most interesting as a chemical fact, since both lactine and lactic acid have the same composition, the only difference being that two equivalents of oxygen and two of hydrogen cease to exist as such in the acid, but may be considered as combined in the form of water with the remaining elements:

$$\text{Lactine } C_{12}H_{12}O_{12} = 2 \text{ Lactic acid } (C_6H_5O_5HO.)$$

M. Pasteur has shown that this lactic fermentation is not merely confined to milk, but that it is a peculiar fermentation, differing from the previous one, which frequently occurs during the decomposition of organic matters, and is due to a distinct ferment of its own; and his researches on lactic fermentation have explained the fact, observed by M. Pelouze some years since, that when a vegetable substance, such as sugar or starch, was put in contact with chalk or other alkali and an animal substance, lactic fermentation ensued, but, until the researches of M. Pasteur, we did not know why sugar and starch in these circumstances should give lactic acid instead of alcohol and carbonic acid, which would be the result of a fermentation produced by yeast. Lactic acid is a most interesting substance to the physiologist, for it is found in larg equantities, free or combined with lime, in gastric juice in the muscular part of animals, or with soda in blood, and its production is easily accounted for when we remember that it can be produced from the starch and sugar existing in our food. When lactic acid is purified by various chemical means, and separated from the fluid in which it is combined, it presents itself as a syrupy fluid of an intensely acid reaction, which, when submitted to the action of heat, first loses its one equivalent of water, and becomes anhydrous lactic acid, and on a further application of heat loses still one equivalent of water, and is transformed into a neutral substance called lactide. This acid in a free state has not yet received any important application in art and manufactures, but I have little doubt that it will some day be largely employed, for we have noticed in a former lecture its advantageous use when produced from rye and other amylaceous substances in removing the lime from various skins intended to be tanned or prepared as there described, and Mr. E. Hunt has used it in the form of sour milk for the conversion of salt into dextrine, (see *Journal of the Society of Arts*, December 23, 1859.) I wish now to say a few words on the mineral

substances existing in whey, and which play a most important part in milk as a nutritious substance. We are all of us too apt to overlook the importance of the mineral elements in food, and to consider as essential the organic matters only. In milk, however, its alkaline salts, and especially the phosphate of lime, are as essential (as food) as caseine or fatty matters, for if an infant requires the lactine to maintain respiration and the heat of the body, the caseine to contribute to the formation of blood, the phosphate of lime is equally essential to the production of bone; permit me here to state that the practice adopted by some mothers of feeding infants upon amylaceous substances, such as arrowroot, sago, tapioca, &c., in place of milk, is most pernicious, for these contain neither flesh nor bone forming element, and milk is the only proper food for infants.

Having now examined the general properties of some of the most important constituents of milk, let us say a few words on that fluid in its integrity. We all know how rapidly milk becomes sour, especially at a temperature of 70° to 90°, and this is owing, as already explained, to the formation of lactic acid. The best way to preserve milk sweet for domestic purposes is to add to it every day a few grains of carbonate of soda per pint to keep the milk alkaline. The possibility of preserving milk for a lengthened period has repeatedly occupied the attention of scientific men, as a most important problem to solve for the benefit of persons undergoing long sea voyages, but, up to a recent date, with very imperfect success. One of the best plans proposed is to add to milk 7 or 8 per cent of sugar, and evaporate the whole, agitating all the time to prevent the formation of the skin, and, when reduced to one fifth its bulk, to introduce it into tin cans, which, after being subjected for half an hour to a temperature of 220°, are hermetically sealed. In 1855, l'Abbé Moigno drew the attention of the members of the British Association, at Glasgow, to milk which he stated contained nothing injurious, and which would keep for a long period. This statement has proved correct, for I have here some milk which has been in the hands of the Secretary of this Society since that period, and which, on being opened to-day, was found perfectly sweet. But if l'Abbé Moigno's process had remained a secret, M. Pasteur has succeeded in affecting the same end, and probably by the same method. Thus, he has found that if milk be heated to 212°, it will only remain sweet for a few days, if heated to 220°, it will remain sweet for several weeks, but if to 250°, (under pressure, of course,) the milk will keep for any length of time. This, according to M. Pasteur, is owing to the spores or eggs which generate lactic fermentation being destroyed by the high temperature, and thus the possibility of fermentation is put an end to. The adulteration of milk by various substances stated to have been discovered therein, has, I think, been greatly over estimated, as I have never found any of them in the samples of milk which I have analysed. In fact, the most easy and cheapest of all is the addition of water. It is comparatively to ascertain if milk has been tampered with, but, without entering into details of the methods necessary to estimate the exact extent of adulteration, I may mention the following plan: If a glass

tube, divided into 100 equal parts, is filled with milk and left standing for twenty-four hours, the cream will rise to the upper part of the tube, and, if the milk is genuine, will occupy from 11 to 13 divisions. Another practical method is to add to the milk a little caustic soda, and agitate the whole with a little ether and alcohol, which dissolves the fatty matters; this etherial solution is removed from the milk and evaporated, when the fatty matters remain, and experience has shown that 1000 parts of good milk will yield 37 parts of fatty matters. Any milk leaving no more than 27 must have been tampered with. Dr. Voelcker suggests the employment of a hydrometer as a means of ascertaining the quality of milk, as the specific gravity of that fluid is an excellent test. From a great number of experiments he has ascertained that good new milk has a specific gravity of 1·030, whilst if good milk is adulterated with 20 per cent. of water, its specific gravity will fall to 1·025.

Urine is a fluid secreted by the kidneys, which organs separate from the blood as it circulates through them any excess of water it may contain, as well as many organic substances which have fulfilled their vital function in the animal economy, and which require to be removed from the system. The composition of urine varies greatly in different individuals, and in the same individual at different times, and is influenced by diet, exercise, state of health, &c., as shown by Dr. Bence Jones and Dr. Edward Smith; but without detailing these variations, which would occupy far more than the limits of a lecture would permit, allow me to call your attention to the following table, showing the composition of human and herbivorous animal's urine:

HUMAN.

Water,	933·000
Urea,	30·100
Lactic acid, Lactate of ammonia, Extractive matter, Kreatine, Kreatinine, Hippuric acid, Indican, Colloid acid,	17·140
Uric acid,	1·000
Mucus,	0·320
Mineral salts,	18·440
	1000·000

HORSES.

Water,	910·76
Urea,	31·00
Hippurate of potash,	4·74
Lactate of do.	11·28
Do. of soda,	8·81
Bicarbonate of potash,	15·50
Carbonate of lime,	10·82
Carbonate of magnesia,	4·16
Other salts,	2·93
	1000·00

The substances in human urine which call for special notice are urea and uric acid; in herbivorous animals, hippuric acid; and in birds, uric acid.

Urea is a substance crystallising in various derivative forms belonging to the prismatic system; it is very soluble in water and alcohol, and gives beautiful and well defined salts with nitric and oxalic acids. Urea, under the influence of a mucous substance secreted at the same time, and which is easily modified into a ferment, is rapidly converted, by the fixation of two atoms of water into carbonate of ammonia, as seen by this formula:

Urea, ...	C_2	O_2	N_2	H_4
Water, ...		O_2		H_2
Carbonate of ammonia, . . .	C_2	O_4	N_2	H_6

This will explain the strong ammoniacal odor arising from urine after being kept for a short time; and as it may be most important for medical men to be able to preserve urine in its normal condition for several days, I observed a few years since a most effectual method of preserving it, which is merely the addition of a few drops of carbolic acid immediately after the production of the urine. Urea is peculiarly interesting to chemists, as it was the first organic substance which they succeeded in producing artificially from mineral compounds. This interesting discovery was made by Wöhler, in 1820, in acting upon cyanate of silver by hydrochlorate of ammonia. Since then, Baron Liebig has devised a more simple process, which consists in decomposing cyanate of potash by sulphate of ammonia, which gives rise to sulphate of potash and cyanate of ammonia, or urea. The average quantity of urea rejected daily by an adult man is about an ounce, or $2\frac{1}{2}$ per cent. of the fluid itself. Although human urine does not contain more than one per cent. of uric acid, and this generally combined with soda, still, I deem it my duty to say a few words respecting it, for it is often the source of gravel and calculus, owing to various influences which make the urine strongly acid before its rejection, whereby the soda is neutralized, the uric acid liberated, and this being nearly insoluble, separates, and has a tendency to form gravel or calculus. In fact, the deposit which occurs in this fluid is generally represented by uric acid, phosphate of lime, and magnesia, mucus, and coloring matter. It may be here stated that calculi were formerly held in great estimation, especially those formed in the intestine, and called bezoards, and this was the case in Eastern countries until very recently. Thus, it is related that a Shah of Persia sent to Napoleon I, among other valuable presents, three bezoards, which were considered to be of great antiquity and capable of curing all diseases. The urine of birds and reptiles being almost entirely composed of urate of lime, explains why their refuse is of such value as a manure, which arises from its transformation into carbonate of ammonia. When large masses of this refuse undergo a slow and gradual decomposition, as in the dry climate of the Pacific Islands, on the coasts of Peru and Chili, it constitutes guano. It may be interesting to know that in 1835–36–37, a most

beautiful color was prepared from the uric acid contained in guano, and used largely by calico printers and silk dyers under the name of Roman purple, or murexide.*

Before leaving the study of this important animal secretion, let me say a few words on the urine of herbivorous animals. It is generally alkaline, and contains, besides an aromatic principle, an acid discovered by Liebig, and called hippuric acid, together with urea and uric acid, also found in human urine. Hippuric acid is easily obtained in the well defined crystals, by rapidly evaporating the fluid containing it. This acid does not exist in the food of the animal; but benzoic acid, or its homologues, are found there, and, during the phenomena of digestion, the nitrogenated principles produced by the wear and tear of life fix themselves on benzoic acid, and convert it into hippuric, as seen by this formula:

Benzoic acid.		Hippuric acid.
$C_{14}H_5O_3+HO$	. .	$C_{18}H_5O_5N_2+HO.$

A further proof of the correctness of this view is that when hippuric acid is treated with strong acids or alkali, it transforms itself into benzoic acid, which can be easily extracted.

(To be continued.)

On the Action of Silicate and Carbonate of Soda in Cotton Fibre.

By F. Grace Calvert, F.R.S., F.C.S.

From the London Journal of the Chemical Society, March, 1865.

I have lately been engaged in investigating a case of injury to goods, which I hope will prove interesting to chemists and manufacturers, from the novelty of the ascertained chemical facts to which the injury is traceable.

A large quantity of blue-tipped indigo cotton goods, with white reserves, were shipped two or three years ago to South Africa, and when opened some time after their arrival, were found so unsound as to be quite unsaleable, the cotton fibres being so much injured as to give way upon the slightest strain. The goods were, therefore, returned to this country, and placed in my hands to investigate the cause which had produced this damage.

As a large number of bales were returned without having been opened abroad, an excellent opportunity offered itself for selecting a well defined series of pieces for experiments, and also for judging of the effects of packing on goods generally, when exposed for a long period to the hot and moist atmosphere of tropical climates.

First, on opening the bales, I observed that the boiled oil cloth which had been employed to protect the goods from external damp, yielded, when subjected to a very slight strain, proving that the texture of the cotton fibre had been injured by the oxidation it had undergone, in consequence of its having been saturated with boiled oil.

Secondly, on examining the goods forming the bales, it was found, in every instance, that the outer folds, including the second, and some-

* See, for further details, my lecture at this Society, February 5, 1862.

times the third, were stained and dirty, but this did not extend deeper, the inner folds being perfectly free from stain or mildew. These facts show the importance of returning to this country (where claims are intended to be made upon the manufacturers or packers) entire and unopened bales of goods, instead of a few sample pieces, which cannot show the state of the bales, and enable the examiner to speak with certainty as to the cause of injury.

I also ascertained that the rottenness of the fabric could not have been caused by their having been packed in a damp condition, for the hygrometric moisture of a piece in the centre did not exceed 8·5 per cent. Further, the goods were carefully examined to ascertain if any mildew could be discovered, which would have occurred if the goods had been packed in a damp state, and which would have certainly developed itself more fully in the interior of the bales than nearer the outside, if damp packing had been the cause. What completely removed from my mind all doubt as to the cause, was that, on carefully examining the pieces composing the bales, I found among the injured pieces, some which were quite sound, and on submitting these pieces to analysis, comparatively with those which were injured, the following results were obtained:

The sound pieces left only from 0·55 to 0·65 of ash, whilst the injured pieces left 8·29 and 8·59 of ash, the composition of which was as follows:

	No. 1.	No. 2.
Insoluble Silica,	2·94	3·81
Silica combined with soda,	2·35	2·53
Soda,	1·77	1·60
Other salts, Sulphate of soda, Chloride of sodium, Sulphate of lead, &c.,	1·23	0·65
	8·29	8·59

These analyses show that the pieces had been finished with silicate of soda, which had undergone a partial decomposition; while the pieces which left only a few thousandths of ash were found, on further examination, to have been finished in the ordinary way, viz: with amylaceous substances. This induced me to examine more minutely the goods, to ascertain whether it was to the silicate of soda, or to the carbonate of soda, arising out of its decomposition, that the injury sustained was due; and I was further prompted to carry on this investigation from the fact that at the present time, the tendency amongst manufacturers is to weight their goods. It is well known that the risk of mildew is considerably increased in proportion to the weight of size; consequently there is a great inducement to use mineral, in preference to vegetable substances for that purpose. I therefore trust that the results now published will warn manufacturers of the risk they run in using mineral size, without great care and experience, whilst on this point I may be permitted to give here an insight into the nature of the size often used in Lancashire for sizing the warps of grey calicos, and, therefore, I give a few of the results obtained at my laboratory.

Analysis of Various Cloths.

No. 1.

Mineral matter, principally clay and sulphate of magnesia,	5·2
Water in excess,	2·8
Fermented flour,	10·0
Hygrometric moisture,	8·0
Fibre,	74·0
	100·0

No. 2.

Mineral matter, principally sulphates of baryta and magnesia,	4·5
Water in access,	2·1
Fermented flour,	11·3
Hygrometric moisture,	8·0
Fibre,	74·1
	100·0

No. 3.

Mineral matter, principally sulphate of soda and clay,	4·8
Flour,	10·0
Water in excess,	4·5
Hygrometric moisture,	8·0
Fibre,	72·7
	100·0

No. 4.

Mineral matter,	1·24
Water in excess,	1·74
Fermented flour,	13·02
Hygrometric moisture,	8·00
Fibre,	76·00
	100·00

The above data show that warps are sized with sour flour (viz: flour which has been allowed to ferment for several days or weeks) and various mineral matters, to the amount, irrespective of moisture, of about 15 per cent. There can be no doubt that goods thus sized are extremely liable to mildew, owing, on the one hand, to the use of fermented flour, or organic matter in a state of decay, and on the other, to the use of clay, which tenaciously retains moisture, which facilitates cryptogamic vegetation when the goods are packed. I may state, *en passant*, that sulphate of magnesia, sulphate of lime, sulphate of baryta, sulphate of soda, and the chlorides of sodium and magnesium are often used, with or without clay, as weighting materials.

On examining the comparative strength of various pieces composing a bale, I observed that the outside folds of the pieces which formed the external parts of the bale (above alluded to as dirty and stained) were comparatively strong when tested against the folds of the same piece which were towards the interior of the bale. I therefore took the same weight of cloth from both classes of folds and submitted them to analysis, with the following results:

	Interior of bale.	Exterior of bale.
Insoluble silica, . . .	4·81	7·08
Silica combined with soda, .	2·53	0·20
Soda, ...	1·60	0·47
Other salts, . . .	0·65	0·55
	8·59	8·30

On examining and comparing these figures, it is at once seen that the stained fold shows a large increase in the amount of insoluble silica, and a corresponding decrease in the amount of silica combined with soda; but, notwithstanding this, the total amount of silica is nearly the same in both classes of cloth. Further, that there is a total disappearance in the stained fold of 1·13 per cent., or more than two-thirds of the total amount of soda. From the results it would appear that the silicate of soda, when first applied to the goods, contained the whole of its silica in combination with the soda, and that, under the influence of the carbonic acid of the atmosphere, the silicate of soda has been decomposed into insoluble silica and carbonate of soda, thereby giving rise to great increase in bulk; whilst in the goods which were protected from an excess of moisture—as towards the interior of the bales, —and also from the action of carbonic acid, there is only a partial decomposition of the silicate of soda. Mr. Walter Crum has kindly suggested, and I believe the view to be correct, that the cotton fibre has, by its organic nature, a cohesive attraction for silica, which enhances the decomposition of the silicate of soda employed to finish and weight the goods.

From these facts we may assume that there were two destructive influences brought to bear upon the cotton fibre: 1st, that of the increase of bulk resulting from the decomposition of the silicate of soda, giving rise to the formation of free silica and carbonate of soda, which exercised a distending and disintegrating action upon the cellular tissue of the cotton fibre, causing it to burst, and necessarily weakening its tensile strength; 2d, the direct and destructive action of the free carbonate of soda upon the fibre. The latter appears to be the principal cause of injury, for in the external folds we have a more complete decomposition of the silicate, as shown in the above figures, by the increase in the amount of insoluble silica, and at the same time a decrease of the soda, amounting, as previously stated, to more than two-thirds of the total weight.

We shall now trace more in detail this interesting decomposition of silicate of soda, and endeavor to show what had become of the soda which had disappeared. To attain this object, a complete series of specimens were obtained from an entire bale, viz: 1, a piece which formed the outside and was stained; 2, some of the paper employed in wrapping the goods, which was in immediate contact with the stained cloth; and 3, some of the flax wrapping placed next to the paper and between the latter and the oil-cloth covering above alluded to. The following are the results yielded by analysis:

	Pieces of Goods.		Paper Wrapping.		Flax Wrapping.	
	No. 1. inside fold.	No. 2. outside fold.	No. 3. in contact.	No. 4. not in contact.	No. 5. in contact.	No. 6. not in contact.
Insoluble silica, . .	4·05	5·65	0·02	0·03	0·04	0·01
Silica combined with soda, . . .	2·21	0·38	0·09	0·02	0·08	8·03
Soda, ...	1·76	0·25	0·85	0·01	0·29	0·02
Other substances, .	1·96	1·91	15·15	15·28	1·19	1·25
Total ash, ...	9·98	8·19	16·11	15·34	1·58	1·31

In examining these results we have again a most striking and marked difference in the amount of insoluble silica and soluble silicate of soda in the two different parts of the same cloth; and, further, where the carbonate of soda has been removed, the folds of the cloth remain comparatively sound. As to the paper wrapping, it is evident that the paper in contact with the goods has absorbed a great part of the soda which was previously combined with the silica, and that the soda is partly in the state of carbonate, and partly in combination with some of the organic matter of the brown paper; for, when some of the paper was treated with water, it yielded a yellowish brown substance which colored the liquid, whilst the part of the same paper which had not been in contact with the goods did not discolor the water in any marked degree. Further, the aqueous solution was neutral and not alkaline, as in the previous case. As to the flax wrapping, the same difference as noted in the paper was observed, viz: that the part of the wrapping in contact with the stained paper and the stained fabric contained carbonate of soda, whilst that which was in contact with the clean paper contained only a trace. In looking over the bales, a piece of cloth was found which had been finished with silicate of soda, and was partly overlapped by another piece, showing one-half of its exterior fold stained and comparatively sound, whilst that half of the fold which was prevented from forming the exterior of the bale by being overlapped by the previous one, was quite tender and rotten, though it showed no signs of any stains or mildew. I also examined a sound piece which had laid in contact with an injured one, and found that in those folds which had been in contact there was in the injured piece less soluble silicate, and in the folds of the sound piece a considerable quantity of carbonate of soda, the presence of which could not be found in the folds forming the centre of it.

Having observed that the reserved white patterns of the blue-dipped indigo cloth were a great deal more tender than the blue portions of the same piece, I carefully cut out a portion of the white parts and submitted them, with the blue parts, to analysis, with the following results:

	White.	Blue.
Insoluble silica, . . .	5·48	3·17
Silica combined with soda, . .	0·18	2·10
Soda, ...	0·78	1·43
Other salts, . . .	1·08	0·67
Total, . . .	7·52	7·37

These figures illustrate the fact that the decomposition of the silicate of soda has been carried on to a much greater extent in the white parts than in the blue; and I am led to believe that the cause of the increased rottenness in the white is due to the printer having used a resist-paste too acid, and having found that the whites were slightly tendered, he endeavored to check the further action of the acid on the cotton fibre (which, as chemists well know, continues until the cotton fibre is completely destroyed) by the employment of a strong solution of silicate of soda, which, being an alkaline salt, was well adapted to neutralize any acid in the cloth and arrest its action. And, as previously, only weak solutions of silicate of soda had been employed for this purpose, the printer of these goods could not have foreseen that the use of a more concentrated solution would result in such serious consequences. The above figures also prove another interesting fact, viz: that the white parts of the cloth contain a much larger proportion of silicate of soda than the blues, thus proving that the dyed indigo fibres, being partially filled with this resinous dyeing material, were not in a condition to absorb so largely the silicate of soda.

Messrs. H. Caro & Dancer, who were also employed to investigate this matter, entertain a different opinion as to the cause of the white parts being more injured than the blues. These gentlemen are led to believe, from their results, that the reason why the whites are more injured than the blues is, that a slow chemical action has ensued between the sulphate of lead remaining from the reserve paste and the silicate of soda, and that a silicate of lead has been formed, and, as this salt occupies a larger bulk than the sulphate of lead previously existing in the fibre, the production of it inside the cellular tissue of the fibre has been the cause of the increased tenderness of the whites. But as these gentlemen are engaged in investigating the question more fully, I shall leave to them the pleasure of publishing their results.

Lastly, I deemed it my duty to make some direct experiments on the action of silicate of soda on cotton fibre. I therefore took some white cotton and dyed a portion of it with indigo. This blue dyed cloth, with a part of the white one, were dipped in a moderately strong solution of silicate of soda, then dried, and a portion of them introduced into a bottle, at the bottom of which a little of water had been placed, and to help the action of the carbonic acid of the *atmosphere*, a slow current of carbonic acid was then passed through the bottles containing the cloths. After three months' time the warps of these samples were tested, and their comparative breaking weights were found to be as follows:

	On an average of 10 essays.
The warps of the unsilicated cloth dyed blue, . .	334
The same silicated, ...	299 284 289

The results leave no doubt that the warps, even during the short period of three months, had been considerably injured by contact with

silicate of soda. In conclusion, I beg to add that I am aware that silicate of soda has been used for finishing colored goods, but when employed it has been in a very dilute state, and therefore its destructive action has not been sufficiently marked to draw the attention of calico printers.

Pharaoh's Serpents' Eggs.—The Preparation of Sulphocyanide of Ammonium.

From the London British Journal of Photography, No. 284.

By referring to the letter of our foreign correspondent, some notice of these curious chemical toys will be found. Mr. C. H. Wood gives the following process for preparing the white powder, and, as his remarks embrace the preparation of sulphocyanide of ammonium, which is used by several persons as a fixing agent for positive prints, we feel that they will be all the more welcome. Describing the toy, Mr. Wood says:

"It consists of a little cone of tin foil, containing a white powder, about an inch in height, and resembling a pastile. This cone is to be lighted at its apex, when there immediately begins issuing from it a thick, serpent-like coil, which continues twisting and increasing in length to an almost incredible extent. The quantity of matter thus produced is truly marvellous, especially as the coil which so exudes is solid and may be handled, although, of course, it is extremely light and somewhat fragile.

"Having a little of the white powder, with which the cones are filled, placed at my disposal by a friend, I submitted it to analysis, and found it to consist of sulphocyanide of mercury. This salt, when heated to a temperature below redness, undergoes decomposition, swelling or growing in size in a most remarkable manner, and producing a mixture of *mellon* (a compound of carbon and nitrogen) with a little sulphide of mercury. The resulting mass often assumes a most fantastic shape, and is sufficiently coherent to retain its form. It presents a yellow color on the exterior, but is black within. The "serpent" shape, of course, results from the salt being burnt in a cone of tin foil.

"Both the mercurous and mercuric sulphocyanides decompose in the same manner, but the mercuric salt, containing more sulphocyanogen, seems capable of furnishing a larger quantity of mellon, and is the one used in the French serpents. A solution of pernitrate of mercury is readily precipitated by sulphocyanide of ammonium, and the mercuric sulphocyanide may be easily so prepared. It is best to use the mercurial solution as strong as possible, and to *keep it in excess* throughout the precipitation. Solution of perchloride of mercury is not so easily precipitated as the pernitrate, probably owing to the solubility of the mercuric sulphocyanide in the chlorides.

"Perhaps I may be excused for adding that sulphocyanide of ammonium, suitable for the above purpose, may be very easily and economically prepared as follows: One volume of bisulphide of carbon,

four volumes of liq. of ammon. fort., and four volumes of methylated spirit are put into a large bottle, and the mixture frequently shaken. In the course of one or two hours the sulphide of carbon will have entirely dissolved in the ammoniacal liquid, forming a deep red solution. When this result is attained, the liquid is boiled until the red color disappears and is replaced by a light yellow. The solution is then evaporated at a *very gentle heat* (about 80° or 90° F.) until it crystallises, or just to dryness. The product is sulphocyanide of ammonium sufficiently pure for the above purpose. One recrystallization in alcohol will render it quite white.

"One ounce of bisulphide of carbon yields, by this process, exactly one ounce of sulphocyanide of ammonium."

Substitute for Blasting Powder.

From the London Artizan, May, 1865.

At Stockholm, several experiments have been made with nitro-glycerine, in order to test its application as a substitute for blasting powder in mining operations. They were considered very successful, the new compound being found to be superior in its effects to the ancient method, and the price considerably less. Among other trials, a hole bored near the summit of a rock to a depth of 23 feet, was charged with 5½ lbs. of nitro-glycerine. Five minutes after the fuze had been lighted a dull report was heard, and enormous blocks were detached from the rock. Several other mines were fired with blasting powder, but their effects were inferior to those of the nitro-glycerine.

Anti-Fouling Composition.

From the London Artizan, May, 1865.

The *Orontes* screw iron troopship, and the *Hector*, screw iron frigate, have both been docked at Portsmouth to examine, and report upon, and replenish the preservative and anti-fouling compositions with which their hulls below the water line were coated when they were last placed in dock. The bottom of the *Orontes* was found to be free of any important accumulation of weeds, but, under the counter of her stern, and in the run of her lines to her screw aperture, she is thickly encrusted with barnacles, and the bottom is dotted all over with patches of rust, the rivet heads in many places showing evident signs of being affected by the copper contained in the "anti-fouling" composition. As a "preservative" to the ship's bottom, the composition appears to have utterly failed. As an "anti-fouling" preparation, the result is rather more favorable, but this slight advantage appears to have been more than counterbalanced by the failure in "protective" qualities to the iron of the ship's bottom. The compositions used on the *Orontes* were the Admiralty's, or Hay's improved. The compositions were payed on the *Orontes*' bottom when she was in dock in August last.

Preservation of Gun Cotton.

M. M. Blondeau makes the following communication to the French Academy of Sciences: Taken gun cotton of good quality, and expose it for about four hours to the action of the vapor of ammonia. The cotton will soon assume a yellow tint, indicating its combination with the ammonia, and after being dried it furnishes a powder which, besides being unalterable at ordinary temperatures and even undecomposable at 212°, (Fahr.,) possesses an explosive force greater than that of ordinary gun cotton.

Results of the Experiments on the Carburation of Coal Gas. By H. Letheby, M. B., M. A., Ph. D., &c., Medical Officer of Health and Gas Analyst for the City of London.

From the London Chemical News, No. 276.

The experiments made during the last two years on the carburation of gas at the street lamps, have developed a number of facts that should be placed on record, for these facts are not merely of scientific interest, they are also of practical value.

A common notion prevails that the use of the carburettors in the public lamps has not been successful. I have, therefore, made it my business to ascertain whether this notion is founded on fact, and if so, whether the failure is due to an imperfection in the principle of the process, or to the manner in which it has been applied.

On the first of these heads it is necessary only to say that, while, on the one hand, it cannot be denied that the use of the carburettors has not given public satisfaction, so, on the other, it must be admitted that, although the process has not been fairly applied, its want of success is by no means so great as is generally supposed.

The principle involved in the process is, beyond all question, a correct principle, in so far as it relates in its application to the very inferior gas of London; but the success of the process is dependent on certain conditions which have not always been fulfilled. It has been ascertained, in fact, that the results of the process are affected by a great number of circumstances, many of which have been either disregarded, or have been placed beyond our control. These circumstances are—the quality of the naphtha, the time of the experiment, the temperature of the apparatus, the form of the carburettor, the quality of the gas, and the rate at which it traverses the instrument. All these circumstances have received attention, and the following are the results of it:

As regards the quality of the Naphtha.—This has a very marked influence on the illuminating power of the naphthalised gas. In point of fact, I have ascertained, by experiment, not only that the different naphthas of commerce furnish different proportions of vapor to the gas, according to their different degrees of volatility, but also that those vapors are endowed with very different degrees of photogenic power. A single grain, for instance, of some of the hydrocarbons to

each cubic foot of common gas will raise its illuminating power to the extent of only about 1·69 per cent.; whereas, a grain of other hydrocarbons will raise it nearly 9 per cent. This is illustrated by the following table, where only a few of very many experiments are recorded:

TABLE *of the Specific Gravity, Boiling Point, Volatility, and Illuminating Power of the various Naphthas used in a common street carburettor, with a batswing burner consuming three feet of gas per hour.*

Specific gravity, water being 1000.	Boiling point (Centigrade.) (deg.)	Amount per cent. yielded by distillation.		Average quantity taken up by each foot of gas, (grains.)	Per centage increase of illuminating power.	
		Up to 130° Cent. (grains.)	From 130° to 150° Cent. (grains.)		Total.	For each grain of Naphtha per cubic foot.
698	63	86	14	20·1	33·9	1·69
676	40	98	2	34·4	62·1	1·80
869	102	76	22	12·1	40.8	3·37
827	115	56	40	6·5	21·7	3·43
808	117	27	53	6·1	21·0	3·60
852	128	4	51	3·8	14·2	3·72
869	107	75	19	9·2	34·9	3·79
869	103	83	14	11·8	46·8	3·96
816	119	15	45	3·4	14·4	4·23
856	114	23	49	4·4	18·9	4·29
814	105	60	34	7·0	33·5	4·78
865	124	9	34	3·3	15·8	4·79
845	90	92	8	12·0	65 3	5·44
874	119	45	37	4·8	26·7	5·56
879	93	92	8	9·5	53·2	5·60
870	129	5	44	2·8	15·7	5·61
862	121	10	45	3·3	20·4	6·16
848	97	77	15	10·2	68·4	6·70
861	117	24	29	2·3	18·8	8·17
875	110	75	20	6·9	60·8	8·81

It would seem from this, that a naphtha with a low specific gravity and a low boiling point is not well suited for the carburation of gas; for, although it yields a large quantity of vapor to the gas, the photogenic value of it is but small. This is the kind of naphtha obtained from the petroleums and shales of commerce, and it has not unfrequently been found in the naphthas supplied to the public lamps. On the other hand, the naphthas obtained from coal tar are much richer in carbon, and are, therefore, better suited for the carburation of gas. But the more volatile of these naphthas are so largely used in the manufacture of red and purple dyes, that it is difficult to obtain them, at a reasonable price, for the street carburettors. I have, therefore, been compelled to specify a quality of naphtha which is not well fitted for the manufacture of dyes; but this also is of a rather low volatility,

and is, therefore, not so good for the carburation of gas as it ought to be. The terms of the specification are, "that the naphtha shall be colorless; of a specific gravity of about 870; of a boiling point not higher than 110° C. (230° Fahr.); and yielding, on distillation, at least 70 per cent. of volatile naphtha, between the boiling point and 130° C. (266° Fahr.); and 20 per cent. between 130° and 150° C. (266° and 300° Fahr.)" This naphtha (the last in the table) furnishes about 7 gr. of hydrocarbon vapor to each cubic foot of gas, at ordinary temperatures, and it raises the illuminating power of the gas about 60 per cent.; in other words, it increases the light of a three-foot batswing burner from about seven candles to eleven, and thus makes three feet of gas of the same value as 4·8. If it were possible to obtain, at a reasonable price, a coal naphtha of a little higher volatility at ordinary temperatures—as, for example, a naphtha yielding about ten grains of hydrocarbon to each cubic foot of gas,—the illuminating power of the gas would be increased about 68 per cent. A gallon of this naphtha will weigh nearly 60,000 grains, and it would be sufficient to naphthalise 6000 cubic feet of gas—making them equal to about 10,000 feet of unnapthalised gas. Such a naphtha, even at 6s. per gallon, would be equal to just three times its money worth of gas; for a gallon of the naphtha costing 6s. would give the light of 4000 cubic feet of gas costing 18s. The only difficulty, at present, in the realisation of this object is, in the uncertain composition of the naphthas of commerce; but this difficulty would soon be overcome if a steady demand for such a naphtha existed. Even as it is, it may be said that the common coal naphthas of commerce increase the illuminating power of the London gas to the extent of about 4·5 per cent. for every grain of naphtha taken up by a cubic foot of gas. These naphthas are obtained at a maximum price of 4s. per gallon, and a gallon will double the illuminating power of rather more than 2600 cubic feet of gas; in other words, we have 4s. worth of naphtha doing the work of about 12s. worth of gas. These are the unquestionable results, not merely of laboratory investigations, but also of carefully conducted experiments at the public lamps in Moorgate Street.

As regards the time or duration of the Experiment.—As all the naphthas of commerce are mixtures of various hydrocarbons of different degrees of volatility, it happens that the most volatile constituents of the naphthas are given up very freely to the gas at the commencement of the experiment, and the less volatile with more difficulty at the end. In consequence of this, there is always a large increase of illuminating power when the carburettor is first charged with naphtha, and a marked diminution of it at last. This irregularity has not, hitherto, been compensated for by a regulated supply of gas; and, therefore, it has happened that when a naphtha yielding, at first, as much as twenty-three grains of hydrocarbon per cubic foot of gas has been used, the illuminating power has been doubled; but, after a time, from the diminished volatility of the naphtha, the power has gradually fallen to less than 25 per cent. Numerous experiments have been made to determine the influence of this circumstance on the value of the process, and the following table is given in illustration of it:

TABLE *showing the differences in the volatility of the Naphtha and the illuminating power of the gas, at different periods of the experiments.**

Quantity of gas passed, (cubic foot.)	Quantity of naptha taken up per foot of gas, (grains.)	Illuminating power in standard sperm candles.		
		Not carburetted.	Carburetted.	Increase per cent.
80	23·2	6·78	13·68	101·7
152	21·6	7·42	14·30	92·8
136	17·6	7·45	13·24	75·1
232	15·6	7·25	12·10	67·0
198	11·6	6·80	10·19	50·0
249	11·5	7·04	10·44	48·3
285	11·5	7·17	10·81	50·1
330	7·4	7·62	10·04	31·8
451	7·3	7·18	9·60	33·7
2113	12·1	7·21	11·60	60·1

The influence of temperature on the carburation of gas.—In the warm weather the volatility of the naphtha is increased, and, therefore, a larger amount of hydrocarbon vapor is given to the gas. A few experiments have been made, at different times of the year, on the street carburettors, with the view of ascertaining the extent of this influence within common ranges of temperature. The following are the results:

TABLE *showing the volatility of the Naphtha, and per centage amounts of increase of illuminating power, according to temperature, at different seasons of the year.*

Season.	Temperature, Fahrenheit.	Quantity of naphtha per cubic foot of gas, (grains.)	Per centage increase of illuminating power.
Spring, . . .	41°	5·25	23·6
Summer, . . .	72°	12·09	54·4
Autumn, . . .	62°	10·77	48·5
Winter, . . .	37°	4·94	22·2

These results show that it is of great importance to keep the carburettors at as uniform a temperature as possible; and it is with this view that the Carburetting Company have placed the apparatus within

* This experiment was made with a street carburettor of the form designed by me, and with 26,000 grains, or nearly four pints, of common naphtha, having a density of 869°, and a boiling point of 103° C., and yielding 82·7 per cent. of distilled product from its boiling point to 130° C., and 14·3 per cent. from 130° to 150° C. The experiment was continued for thirty days and nights, and the gas was continually burning from a three foot batswing burner, the temperature of the room being 22° C. (72° F.)

the lamps, thinking that, in such a situation, a common and uniform temperature of about 60° would be maintained. There is, however, a better situation at the top of the lamp, where the temperature, at the the time of carburation, would be very uniform at all seasons of the year, and where the apparatus would be entirely out of sight.

As regards the form of the apparatus.—Experiment has proved that the form of the apparatus has a very marked influence on the carburation of the gas; for when the instrument is so constructed that the gas merely passes into the chamber containing the naphtha, without sweeping over the surface of the liquid, a very small proportion of the volatile hydrocarbon is taken up. On the contrary, when the gas is brought into contact with a large surface of naphtha, it becomes highly charged with the vapor, and acquires a high illuminating power. In the course of the experiments which have been made for the purpose of estimating the value of this influence, four kinds of carburettors have been used, namely:

1. A single chamber, containing naphtha, with an inlet and exit pipe for the gas at the apex of the apparatus.

2. The carburettor supplied by the Carburetting Company, which is contrived to make the gas flow once over the surface of naphtha before it leaves the chamber.

3. A carburettor contrived by me, which has a series of septa for making the gas pass many times over the naphtha before it leaves the apparatus.

4. A carburettor of M. Mongruel, and also one of M. Nordhoff, both of which contain septa of cotton threads, saturated with naphtha, through which the gas must pass, and so become highly charged with vapor before it leaves the chamber.

In operating with each of these carburettors, under the same circumstances, and with the same naphtha, namely, that supplied according to the contract, it was found, that while the first form of apparatus gave only 3·2 grains of naphtha per cubic foot of gas, the second gave 6·0 grains, the third, 12·1 grains, and the fourth, from 22 to 23 grains. It is manifest, therefore, that to secure a uniform supply of hydrocarbon vapor, it is necessary to bring the gas into contact with a large surface of naphtha.

The quality of the gas affects the carburation.—When gas is already charged with a large proportion of the richer hydrocarbons, it manifests no disposition to take up the vapor of naphtha—on the contrary, if it be a cannel gas of very high illuminating power, the naphtha will deprive it, to a certain extent, of its hydrocarbons, and so render it weaker,—the process, therefore, is only applicable to such a poor gas as that which is supplied to the city; and, even in the case of this gas, it has been noticed that when a dose of naphtha has been already given to it, it does not show the same tendency to absorb the vapor as it did before.

The carburation of the gas is affected by the rate at which it traverses the apparatus.—This might be easily perceived from the circumstance that the longer and more completely the gas is brought into

contact with the naphtha, the more fully it becomes charged with its vapor. Experiment has shown that when in the same carburettor the gas is burnt at the rate of 3 feet per hour and the light is increased to the extent of 41 per cent., it will be only increased to 34 per cent. if it is burnt at the rate of 3½ feet per hour; but this difficulty is easily overcome by increasing the surface of naphtha.

In conclusion, therefore, it may be said, that although the success of the carburetting process is evidently dependent on many conditions, yet, as all these conditions are under control, there is no reason that they should not be at all times fulfilled, and the success of the process secured. One thing, it will be observed, is beyond all question, and that is, that every grain of common coal naphtha given to a cubic foot of gas increases its illuminating power about 4·5 per cent., (a good naphtha will increase it about 8 per cent.;) and this grain of naphtha costs only about one-third of its equivalent in London gas.

Nitro-glycerine.

We extract the following information in reference to this compound, which appears destined to play an important part in the arts, from the *Annales du Genie Civil:*

Nitro-glycerine is the product of the reaction which ensues when glycerine is slowly poured into a mixture of concentrated nitric acid, with twice its bulk of oil of vitrol. The glycerine loses three equivalents of water, which are replaced by three of nitric acid. It is called by its discoverers, *trinitrine*, *trinitro-glycerine*, *&c.*

It is a liquid of specific gravity 1·6, nearly insoluble in water, easily soluble in alcohol and ether. It has great stability and keeps indefinitely; foreign bodies do not favor its decomposition; at ordinary temperatures it even remains unchanged in presence of phosphorus and potassium. It does not explode by flame; burns by contact with an ignited body, but ceases to burn so soon as the contact is at an end. It explodes only at 360° Fahr. It detonates by a violent blow of a hammer, but only the part submitted to the blow explodes, without action on the surrounding liquid.

MM. Sombrero and Williamson first described the properties of this interesting liquid. M. A. Nobel first suggested its uses in blasting. In Sweden it has been used in place of gunpowder for more than six months. Its principal advantages are the following:

1st. Being insoluble in water and heavier than it, it can be used in wet mines or under water.

2d. Not exploding by contact of an ignited body unless strongly compressed, it may be carried, kept, and handled without danger.

3d. Its expansive force being ten times greater than gunpowder, it economizes labor.

4th. The rapidity of its explosion renders tamping of no importance, and thus renders the miner perfectly safe.

5th. It is as efficient in a soft and crumbling stone as in a hard and compact one. It leaves no residuum.

Notes on Magnesium. By Alonzo G. Grant.

From the British Journal of Photography, No. 281.

It is with much diffidence that I attempt to communicate what little information I possess concerning magnesium and some of its appliances and recent developments. I cannot do better than commence with Sonstadt's patent, which consists of a cheaper and quicker method of separating and refining the metal from the magnesium limestone than formerly practised.

Apart from a knowledge of its existence as a scientific curiosity, my attention was first called to this comparatively new metal by Mr. Baldwin, who was engaged in making a few specimens of jewelry for Mr. Sonstadt, whose original idea, I believe, was that it would, to some extent, supersede silver. A few experiments soon put to rest that question, as it was found too soft and highly corrosive for ornamental purposes.

Magnesium next came before the public as a metal which ignited readily, and produced the highest quality of actinic light. As might have been expected, photographers were not slow to avail themselves of this property.

A lamp for the proper and regular combustion of the metal was next required, and I, in common with some others, have endeavored to supply that demand. That my efforts have been appreciated is apparent from the fact that my lamps have been in much request.

Although, by means of clockwork, I have succeeded in securing a steady and continuous light, yet the dense smoke emitted from the combustion of the metal has hitherto proved objectionable. I have partially succeeded in destroying the smoke and ashes by mechanically forcing them through diluted sulphuric acid, but as yet I have not applied this to the lamp, owing to the danger accompanying the use of acids.

The lamps have been used for assisting the action of daylight in the taking of portraits; and, in some cases, good artistic portraits have been taken by them without daylight. They have, too, been used in photographing the interior of the Pyramids of Egypt, copying the signatures of wills, &c.; and the latest application is the photographing of the sections of the interior of lead mines, to show the average quantity exposed, also the different kinds of veins which the miners are following. I have here a few specimens of this application, taken in the Wasses Mill-Close Mine, 140 yards deep, exhibiting the end of two pipe veins, and photographed to scale, showing a surface four feet by six feet.

There is something else which has recently been definitely settled by a series of experiments by T. W. Keats, Esq., F.C.S., and myself, and which show the penetrating visual power of the light to be as follows:

When the lamp is charged with four wires, weighing three grains each per foot, and the regulator is set to run out eight inches per

minute, the consumption, according to this is eight grains per minute, producing light without a reflector equal to 288 sperm candles, six to the pound, burning 576 grains of sperm per minute. Compared with London gas this is equal to 21¼ Argand burners, consuming 288 cubic inches of gas per minute, and by the use of a parabolic reflector the light is very much increased on any given point. One experiment has come to my knowledge in which a similar lamp was successfully used for signalling at a distance of 14 miles.

An important use of the lamp is its application to light-houses. It is also successfully used in Chadburn's opaque lantern for exhibiting colored photographs on a screen any size, reproducing all the colors.

Self-acting Pressure and Draft Regulator. By MM. MONTI, BONNETERRE, and ERHART.

In its simplest form, this apparatus is composed of a spiral copper tube, 0·8 inch in diameter, leading from the boiler into a condensation chamber, of the form of a truncated cone, and divided by an india rubber diaphragm. This arrangement is that used for pressure gauges. To the lower part of this chamber is attached a pump, whose piston carries a point which presses on a lever of the third order, whose long arm controls the register of the furnace, and is counter-weighed by an adjustible weight. The steam coming in by the copper tube undergoes condensation, and the upper part of the chamber fills with water under the pressure of the boiler. The counterpoise of the lever being adjusted to the maximum pressure allowed, if this pressure be exceeded the steam will press through the water and diaphragm upon the piston, whose point acting on the lever will close the register by a quantity proportioned to the increased pressure. The drafts being diminished, the pressure will fall, and the piston being drawn back the counterpoise will reopen the regulator. This ingenious device is said to have been adopted in several establishments in Paris, and to give an economy of from 10 to 15 per cent. in fuel. *Cosmos.*

New Green Avanturine Glass.

M. Pelouze recommends as a beautiful variety of ornamental glass one composed as follows: Sand, 250 parts; carbonate of soda, 100 parts; carbonate of lime, 50 parts; bichromate of potassa, 40 parts. This glass melts with perceptibly greater difficulty than that without the bichromate, is of a deep green color, and full of small spangles, crystals of oxide of chrome, which sparkle with a brilliancy inferior only to the diamond. As it resembles in character the Avanturine glass of Venice, M. Pelouze proposes for it the name of Chrome Avanturine. *Acad. Sciences, Paris.*

Electric Buoy.

M. Duchemin proposes to construct Ampêre's electric boat upon a sufficiently large scale, and to use it as a warning buoy on shoals, &c. He proposes to float, by means of cork, a carbon cylinder within a hollow cylinder of zinc, the connecting wire to be made to strike a bell in the usual way. He speaks of *small* cylinders, but gives no suggestion as to the size necessary to operate a bell large enough to be heard at any distance.

The Stereo-phantasmascope.

From the London British Journal of Photography, No. 280.

Perhaps the most expressive description of the reality of the scene which the stereoscope presents to our senses is conveyed in the brief but terse words of *The Times*—"Seems? nay, *is!*"

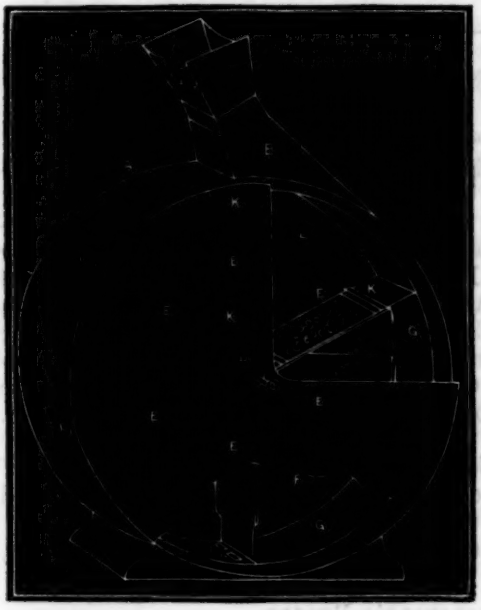
To increase still more the delusion under which, for the time being, a person labors while inspecting a stereoscope picture, attempts have been made to add to the already marvellous relief of the images in the stereoscope, the additional marvel of apparent motion. For several years binocular pictures have been vended in our bazaars and print-shops, in which the effect of motion is obtained in the following manner: If it be required to produce a reciprocating motion, such as a smith engaged in hammering a piece of metal, one view of the pair is taken with the hammer raised, and the other with it down upon the metal then being operated upon. So with sawyers at work; in one view the saw is up, in the other it is down. Other subjects of a similar nature will readily suggest themselves. To see these *in motion*, the most ready way is to wave between the eyes and the picture a piece of cardboard, or any similar material, which will have the effect of allowing only one picture to be seen at a time, when, on account of the *persistence of vision*, a stereoscopic image will be seen of an object in apparent motion.

In the cases which we have cited, the motion, it is obvious, will not be of a continuous nature, seeing that only the two extremes of the motion are represented. When more than two positions are to be depicted, some arrangement must be made by which each picture in succession can be presented to the eye.

There is a well known optical toy, the *phenakitiscope*, in which a series of pictures of the objects to be exhibited in motion are pasted on a disc, which is made to revolve, and the pictures on which are viewed through a slit. This instrument has been employed by our ingenious friends on the other side of the English Channel for the exhibition of "moving photographic images." The defects inherent in this method of viewing stereographs are very ably set forth in an interesting paper by M. Claudet read last week in one of the sections of the British Association, which will be found in the present number of the *Journal*, and to which we invite the attention of the reader.

It does not, however, appear to be generally known, that an instrument was invented and patented in America some years ago, by which the effects of either rotary or reciprocating motion can be exhibited in perfect stereoscopic relief. The instrument was, at the time of its invention, described by Mr. Coleman Sellers, of whose fertile brain it is the offspring; yet, seeing that the subject has been deemed worthy of being brought before the notice of the British Association, an apology is hardly required for again reviving the subject, and giving a description of Mr. Seller's *phantasmascope*, by means of which we have seen, in all the stereoscopic relief of nature, a mill wheel majestically revolving with beautiful regularity.

One form of phantasmascope consists of a cylinder D, not more than an inch in diameter, around which are arranged six wings, E E, like the paddles of a water-wheel, and on these wings the stereographs are fixed.



Around the outside of these wings passes a band of tin, G, four inches wide, through which are cut slits, I I, each a quarter of an inch wide and an inch long, the centre of each pair of slits being three inches apart. These slits are close to each of the wings and immediately at the back of each picture, so that through the slits may be seen the picture on the face of the next wing. The ordinary stereoscopic prisms placed at C C combine the pictures as they pass in succession before the eye. The whole of each picture cannot be seen at one time, but according to whether it is turned to or from the observer, so the picture is seen at its lower or upper edge first, and then the vision passes over the card, which has scarcely gone before another is presented to the view. On account of the "persistence of vision" the pauses between the pictures are not perceived.

By the instrument which we have just described, the most wonderful effects of combined motion and relief are obtained; and we are glad of this opportunity of again calling attention to the ingenious and, perhaps, partially forgotten phantasmascope of our friend, Mr. Sellers, and of testifying to the ingenuity displayed in this interesting instrument.

Another new Process of Engraving.

From the London Builder, No. 1150.

A layer of finely pulverized chalk is compressed and smoothed by hydraulic power on a metal plate. The artist draws on this with an ink which makes the lines hard. A soft brush or a piece of velvet rubbed over the plate leaves the inky portion in relief. The whole plate is then saturated with a chemical solution, which turns the chalk into stone, somewhat analogous to Ransome's principle seemingly. From this, impressions may be taken, or stereotypes or electrotypes obtained. The cost of these "graphotypes" is said to be something like one-tenth the cost of wood-blocks, to which the *Morning Herald* says they are fully equal; but whether this process be likely to come to anything practical, or whether it is to follow so many others into oblivion, we cannot yet say; surely something useful will come of all these inventions at last.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, November 15th, 1865.

The meeting was called to order with the President, Mr. Wm. Sellers, in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported, including the following donations to the library: From the Chemical Society, the Statistical Society, the Society of Arts, and the Royal Geographical Society, London; the Natural History Society, Montreal, Canada; Young Men's Association, Milwaukie, Wisconsin; the Commissioner of Agriculture, Washington, D. C.; the Legislature of Pennsylvania; the Schuylkill Navigation Company, Wm. Biddle, and Prof. John F. Frazer, Philadelphia.

The minutes of the various Standing Committees were reported.

The Special Committee on experiments in steam expansion, reported progress.

The Report of the Secretary on new discoveries and inventions, &c., was then read as follows:

Secretary's Report.

Engineering Works.—The tunnel for supplying Chicago with water from Lake Michigan is making steady and rapid progress, the average rate being 12 feet per day. The cribs for the inlet pier, about two miles out from shore, have been successfully placed, and the iron tubing for the descending shaft at that point is in a finished state.

The Barmouth viaduct, crossing the mouth of the river Maw, North Wales, is a work of considerable extent now in course of construction. Its length is one mile; 770 yards consists of a solid embankment, 740 are of timber, divided into 117 spans of 19 feet each, 109 yards of iron, divided into 7 spans of 40 feet each, and one of 47 feet.

It appears from a paper read before the Mechanical Section of the British Association, during their late meeting at Birmingham, that a coal-cutting machine worked by compressed air has been successfully operated in a colliery (the Blaina works) upon coal of a very refractory and unpromising character. Its rate of cutting is 8 yards per hour, 3 feet deep. The great advantage of compressed air, as a motor for such machines, is its effect upon the ventilation of the mine, while its great drawback is the loss of power consequent upon the loss of the heat developed by the compression, which is largely abstracted before the air reaches the scene of its labors.

A regulating stopcock for use with burning gas and fluids generally, invented by G. G. Percival, of this city, has been this evening submitted to your notice. Its novel feature consists in the insertion of a set screw into a lug on the barrel of the cock, which arrests the motion of the lug which has a pin or plug attached to it in the manner already generally used. By turning this set screw, its projection through the lug is altered so that it arrests the motion of the plug at a different point, and thus the opening of the cock may be regulated.

This is of consequence, 1st. In public buildings, where the lowering of the lights with a common cock is a matter of great difficulty.

2d. In hotels, and even in private houses, waste of gas often occurs from turning the cock too far. This is rendered impossible in this cock by so arranging the set screw that it can only be turned by a key in the possession of the proprietor, or other responsible person, the movement of the cock being then limited by a proper adjustment, cannot be made to exceed this bound by any one else.

3d. Where consumption of gas is calculated by the "average meter system," this contrivance furnishes an easy means of adjusting different burners to a proper average.

Chemistry.—An improvement in the process for extracting precious metals from their ores by amalgamation has been introduced by Professor Crooks, the discoverer of thalium, and the editor of the *Chemical News.*

This consists in the addition of a very small quantity of sodium to the mercury. By this means, its power of extracting the valuable metal is increased, first, we believe, because its cohesion is decreased, making adhesion to other bodies easier; second, because the strong chemical affinites of the sodium for common impurities keep these from the mercury; and, lastly, because the attraction of this and like amalgams for metals is very strong. Thus we have often noticed the tenacity with which a sodium or potassium amalgam will adhere to the blade of a penknife when preparing this mixture for the development of the ammoniacal amalgam; and with this last substance have even made iron filings into a consistent ball.

From a paper read before the British Association, by Dr. D. S. Price, we learn that the blackening effect produced on lead paint by sulphuretted hydrogen may be counteracted or removed by free exposure to sunlight.

Contact with sodium or potassium causes instantaneously the explo-

sion of gun-cotton, according to Mr. W. S. Scott, in a paper read before the British Association at their last meeting. We would call attention to the methods of printing (mechanically) photographs, invented by Messrs. Walter Woodbury and J. W. Swan, independently, which form the subject of an interesting paper, in the Mechanics' Magazine, for September, page 194.

Messrs. Paul and Ernest Depouilly have published a new method of obtaining benzoic acid from naphthaline. The naphthaline is oxidized into phtalic acid; this is combined with lime to form a neutral salt; this is then mixed with an additional equivalent of lime, and heated to 626° or 662° for ten hours in iron cylinders which are immersed in a bath of lead.

A platinum medal has been awarded by the Parisian Society for the Encouragement of Industry to M. Ozouf, a celebrated manufacturer of soda and other effervescent waters, for a process by which pure carbonic acid may be readily supplied. Coke being burned in an appropriate furnace, the carbonic acid generated is absorbed in a solution of carbonate of soda, which is thus converted into bicarbonate. By heating this, the second equivalent of $C O_2$ is disengaged, and the solution is then ready for a fresh dose of the gas.

Another substitute for india rubber has made its appearance under the name of Parkesine, which is prepared as follows: Gun-cotton is dissolved in wood naphtha and mixed with oil or resin; it is then vulcanized by use of chloride of sulphur, and may be readily colored by the aniline dyes. Many beautiful specimens of this substance were exhibited at a late soirée of the British Association. We should think that the cost of the materials used would prevent any general application of this compound.

Mr. R. W. Artlett has been experimenting largely with the process for preparation of oxygen from hypochlorite of lime, (CaO, ClO,) mentioned a few months since, and finds that oxides of copper and iron act like that of cobalt in liberating the oxygen from the lime salt. A few drops of nitrate of copper will serve for this purpose.

Another process for oxygen is announced by a M. Carlevaris. This consists in heating together black oxide of manganese and silica, ($MnO_2 + SiO_2$,) when silicate of manganese is formed, and one equivalent of oxygen set free, ($MnO, SiO_3 + 0$.)

The equivalent of niobium has lately been determined by Deville and by Blomstrand; the former makes it 47 or 48·3, the latter 39.

Night photography having been introduced by means of magnesium, seems to be extending its range of applications, with other bodies. By burning ¼ of a pound of a mixture containing phosphorus and nitre, which continued its combustion six minutes, a Mr. Wilkinson, of Chelsea, succeeded in taking a picture of a windmill at the foot of his garden, and even found the neighboring houses to "come up" with great sharpness.

Photographs of the interior of a lead mine have been successfully taken in England by Mr. Alonzo Grant. One in the Wasses Mill-Close Mine, shows two pipe veins and the surrounding surface over an area of 4 by 6 feet.

The photographing of the interior of the Pyramids, by Prof. Piazzi Smith, has not proved successful in an artistic point of view, on account of the extremely vitiated state of the air within the close passages constantly visited by travelers with numerous torches and candles, by reason of which the magnesium wire burned with much impaired brilliancy. Some limited views, sufficing however to establish disputed measurements, were taken, though only one picture could be obtained within twenty-four hours, the magnesia smoke requiring this time to settle. A mixture of magnesium filings and mealed powder was said to produce a better effect than the wire.

The following comparison of the magnesium wire with other sources of light is of interest. Four wires weighing three grains per foot, each burning at the rate of eight inches per minute, or eight grains in that time, give a light equal to 288 sperm candles, or 21¼ Argand gas-burners. At this rate of consumption one ounce of wire, costing $6·50 would last one hour.

British Journal of Photography.—A curious French toy has lately been exciting much attention. It is called the egg of Pharaoh's serpent, and consists of sulpho-cyanide of mercury made into a little conical pellet like a pastel. This being ignited, burns with a blue flame giving out a long coil of a consistent material resembling a snake in its length and convolutions, and seemingly a hundred times larger than its parent egg.

Professor John F. Frazer here showed the operation of some of these serpent eggs, prepared by the Messrs. Wyeth, and explained their action, as, also, the history of the substance mellon which is the bulky product of their combustion.

Mr. Coleman Sellers showed some others made by Messrs. Bullock & Crenshaw.

The meeting was then, on motion, adjourned.

H. Morton, *Secretary.*

BIBLIOGRAPHICAL NOTICE.

The Practical Entomologist. A monthly bulletin published by the Entomological Society of Philadelphia, for gratuitous distribution among farmers and agriculturists.

A very neatly printed journal, apparently devoted to the distribution of information on the subject of insects noxious and useful (?) to plants and farmers.

We do not doubt the value of the knowledge thus disseminated, and we believe that the gratuitous distribution by the Society may carry it where it will be useful. At all events, we are glad to see this indication of health and energy in this young Society.

ERRATA.

Page 351, line 6 from top, for "inclends," read "materials."

A Comparison of some of the Meteorological Phenomena of OCTOBER, 1865, *with those of* OCTOBER, 1864, *and of the same month for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57¼′ N.; Longitude 75° 11¼′ W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	October, 1865.	October, 1864.	October, for 15 years.
Thermometer—Highest—degree, .	78·00°	75·00°	90·00°
" " date, .	10th.	6th.	4th, '58.
" Warmest day—mean,	73·17	71·50	78·30
" " " date,	10th.	6th.	6th, '61.
" Lowest—degree, .	37·00	36·00	28·00
" " date, .	25th.	10th.	25th, '56.
" Coldest day—mean,	44·83	44·83	35·80
" " " date, .	25th.	22d.	27th, '59.
" Mean daily oscillation,	11·23	13·16	15·28
" " " range, .	5·13	4·56	5·41
" Means at 7 A. M., .	52·55	50·11	51·28
" " 2 P. M., .	60·15	59·37	62·84
" " 9 P. M., .	54·85	53·18	55·31
" " for the month,	55·85	54·22	56·48
Barometer—Highest—inches, .	30·225 ins.	30·022 ins.	30·452 ins.
" " date, . .	30th.	3d.	25th, '61.
" Greatest mean daily press.	30·209	30·015	30·378
" " date, . .	30th.	3d.	25th, '61.
" Lowest—inches, . .	29·155	29·218	29·012
" " date, . .	15th.	28th.	26th, '57.
" Least mean daily press.,	29·226	29·294	29·059
" " date, . .	19th.	28th.	26th, '57.
" Mean daily range, .	0·171	0·129	0·144
" Means at 7 A. M., .	29·778	29·715	29·906
" " 2 P. M., .	29·746	29·674	29·865
" " 9 P. M., .	29·786	29·726	29·892
" " for the month, .	29·770	29·705	29·888
Force of Vapor—Greatest—inches,	0·527 in.	0·703 in.	0·731 in.
" " " date, .	11th.	6th.	7th, '61.
" " Least—inches, .	·132	·138	·065
" " " date, .	29th.	9th.	21st, '59.
" " Means at 7 A. M., .	·293	·278	·314
" " " 2 P. M., .	·281	·285	·340
" " " 9 P. M., .	·298	·300	·323
" " " for the month,	·291	·288	·326
Relative Humidity—Greatest—per ct.,	94·0 per ct.	91·0 per ct.	97·0 per ct.
" " " date,	18th.	2d.	often.
" " Least—per ct.,	34·0	36·0	23·0
" " " date, .	29th.	14th.	21st, '59.
" " Means at 7 A. M.,	70·5	72·7	77·7
" " " 2 P. M.,	51·7	53·9	56·1
" " " 9 P. M.,	66·5	70·6	72·9
" " " for the month	62·9	65·8	68·9
Clouds—Number of clear days,* .	11	12	9·7
" " cloudy days, .	20	19	21·3
" Means of sky cov'd at 7 A. M.,	51·0 per ct.	54·8 per ct.	56·3 per ct.
" " " " 2 P. M.,	57·1	64·8	55·7
" " " " 9 P. M.,	38·1	34·5	39·8
" " " for the month	48·7	51·4	50·6
Rain—Amount,	3·358 ins.	1·727 ins.	2·888 ins.
No. of days on which Rain fell,	6	8	8·8
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* Sky one-third or less covered at the hours of observation.

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